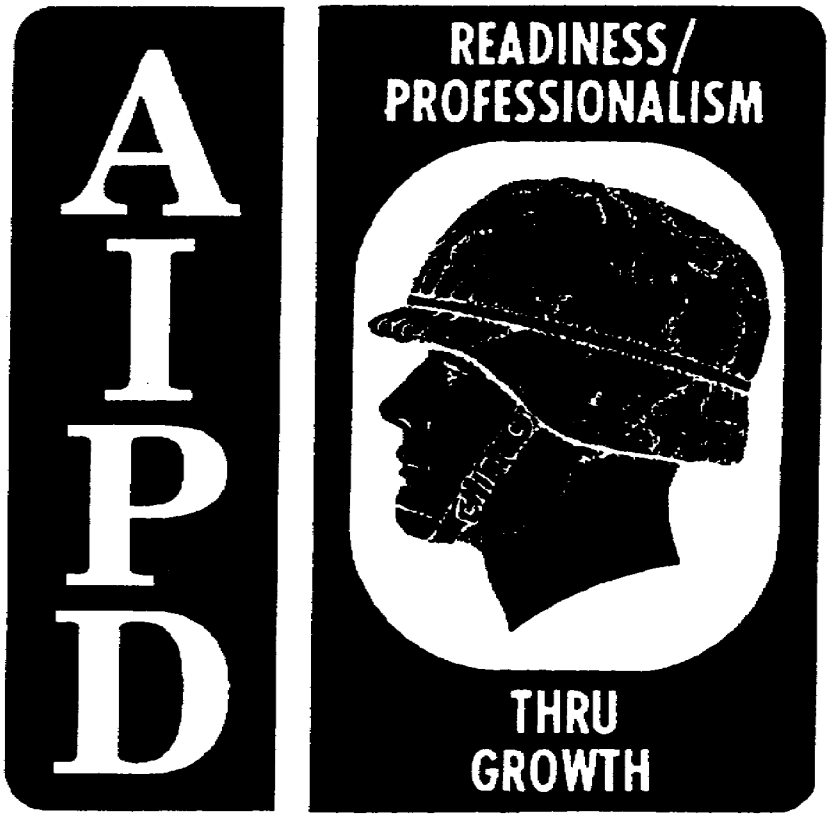
SUBCOURSE
OD0017

EDITION
9

SUPPORTING SERVICES



THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT

ARMY CORRESPONDENCE COURSE PROGRAM

SUPPORTING SERVICES

Subcourse OD 0017
Edition 9

8 Credit Hours

United States Army Combined Arms Support Command
Fort Lee, VA 23801-1809

INTRODUCTION

The age we live in has been called the mechanical age. This is understandable when we realize that nearly everything we use in our present day living is, more or less, machine made. The age, therefore, being mechanical, needs men with mechanical knowledge - knowledge of tools (handtools and measuring tools), pipefitting procedures, procedures for welding and cutting equipment, brazing, and soldering.

Each tool can be traced to a basic named tool that has, in many cases, been in use for thousands of years. As time progressed, the types of tools and equipment changed to a more complicated and mechanical mode.

This subcourse will enable you to learn the basic tools and equipment used in a maintenance shop. It is not intended to cover all tools used by a mechanic, but it will give you a job knowledge needed to perform your duties.

This subcourse consists of three lessons and an examination organized as follows:

Lesson 1 Common Use of Hand and Precision Measuring Tools
Scope - Knowledge of tools, uses, and care to include inspection and limited repair.

Lesson 2 Pipefitting Procedures
Scope - Function, nomenclature, and procedures of pipefitting.

Lesson 3 Introduction to Welding, Cutting, Brazing, and Soldering
Scope - Principles and procedures of welding and cutting equipment, brazing, and soldering.

Please Note: Practice Exercises appear throughout each of the lessons. Refer to Page iii for complete instructions.

CHECKLIST OF TEXTS AND MATERIALS FURNISHED

Ordnance Subcourse OD 0017

No texts, other than the Attached Memorandums in lessons, are used in support of this subcourse. Therefore, you are not required to return any texts to the US Army Ordnance and Chemical Center and School.

This subcourse may contain errata sheets. Make certain that you post all necessary changes before beginning.

Note. - Any references cited in this subcourse are general references and are not furnished. The following publications were used in the preparation of this subcourse:

TM 9-237, Operator's Manual: Welding Theory and Application
TM 9-243, Use and Care of Handtools and Measuring Tools
Special Text 9-167, Soft Soldering
Special Text 9-189, Metal Body Repair and Blacksmithing

INSTRUCTIONS FOR USE OF ANSWER SHEET

LESSON EXERCISE QUESTIONS

1. GENERAL. The procedure by which you will answer the exercise questions in this subcourse is probably new to you. The information is presented in a programmed instruction format where you immediately know whether or not you have answered the questions correctly. If you have selected an incorrect answer, you will be directed to a portion of the study text that will provide you with additional information.

2. PROCEDURE.

a. Arrange this subcourse booklet and your answer sheet (located at the end of the last lesson) so that they are convenient. Each exercise question has three choices lettered a, b, and c. Your answer sheet has three groups of numbers for questions 1 through 200. The numbers indicated for each question represent the a, b, or c choices.

b. Read the first exercise question and select the choice you think answers the question correctly. Go to the question 1 area of your answer sheet and circle the 3-digit number that corresponds with the choice you selected.

c. After you have identified the 3-digit number, locate it in the exercise response list. If you selected the right choice, the first word of the response will be "CORRECT." This tells you that you have answered the question correctly. Read the rest of the response which tells why your choice was correct and then go to the next question.

d. If the word "CORRECT" is NOT the first word of the response, you have selected the wrong answer. You will find the information necessary for you to make another choice. Line out the incorrect 3-digit response on your answer sheet.

e. After you have reread the reference, select another answer and circle the 3-digit response for that choice. Again check the number for this second choice with the response list to see if your choice is now correct and to obtain more information about your choice. If your second choice is still not correct, line out the 3-digit response on the answer sheet and continue until the correct answer is selected. When you have answered all of the questions in an exercise, count the number of lined out responses and see how well you did.

f. You will notice that the lesson exercise question numbers continue consecutively from lesson to lesson. This allows you to use one answer sheet for the entire subcourse. Retain the answer sheet for your reference.

CONTENTS

			Page
INTRODUCTION			i
CHECKLIST OF TEXTS AND MATERIALS FURNISHED			ii
DIRECTIONS TO THE STUDENT			iii
LESSON	1.	COMMON USE OF HANDTOOLS AND PRECISION MEASURING TOOLS	1
	2.	PIPEFITTING PROCEDURES	53
	3.	INTRODUCTION TO WELDING, CUTTING, BRAZING, AND SOLDERING	93
ANSWER SHEET			147
RESPONSE LIST			149

LESSON ASSIGNMENT

Ordnance Subcourse No 017.....	Supporting Services
Lesson 1.....	Common Use Handtools and Precision Measuring Tools
Lesson Objective.....	After studying this lesson you will be able to: 1. Describe types, uses, and care of common handtools and precision measuring tools. 2. Explain inspection and limited repair procedures.
Text.....	Attached Memorandum
Materials Required.....	Response list and answer sheet
Suggestions.....	Study each figure as you read the text.

ATTACHED MEMORANDUM

SECTION I. GENERAL

1. INTRODUCTION. This lesson discusses some of the more common handtools and measuring tools used by maintenance personnel. As your knowledge of these tools increases, so will the proficiency of your shop. The job that will leave your shop will be of the highest quality because of the correct maintenance supervision given to the equipment under your control. Tools are one of man's greatest assets. The proper use of tools makes all jobs easier. The skill of the hands can be increased and the power multiplied by the use of a variety of tools that man has been designing and improving since the beginning of time. A mechanic should acquire a great deal of pride in the ability to use and maintain his tools well.

2. DEFINITIONS. Handtools are defined as hand powered and hand operated tools that are designed to perform mechanical operations. Measuring tools are defined as tools that will measure work. Measuring tools can be classed as precision and nonprecision.

3. SAFETY PRECAUTIONS (GENERAL). It is extremely important for all concerned to recognize the possibilities of injury when using handtools and measuring tools. The following safety precautions are included as a guide to prevent or minimize personal injury:

a. Make certain all tool handles are securely attached before using them.

b. Exercise extreme caution when handling edged tools.

c. Do not use a tool for a purpose other than that for which it was intended.

d. Do not handle tools carelessly-carelessly piling tools in drawers, dropping tools on hard surfaces, etc, can damage tools. Damaged tools car. cause mishaps.

e. Keep your mind on your work so that you do not strike yourself or someone else with a hammer or sledge.

f. Do not carry edged or pointed tools in your pocket.

g. Always wear goggles when chipping metal and when grinding edges on tools.

h. Hold driving tools correctly so that they will not slip off the work surface.

i. Use the right tool for the job. The wrong tool may damage materials, injure workers, or both.

j. Do not use punches with improper points or mushroomed heads.

k. Do not use a tool that is oily or greasy. It may slip out of your hand causing injury.

1. When using jacks, make certain to use blocking or other supports when lifting a vehicle, in case of jack failure.

m. Make sure work to be cut, sheared, chiseled, filed, etc, is steadied and secure to prevent the tool from slipping.

n. When using a knife, always cut away from your body, except in the case of a spoke shave or draw knife.

SECTION II. COMMON USE HANDTOOLS

4. NONEDGED HANDTOOLS.

a. General. These tools are termed nonedged handtools because they are not used for cutting purposes and do not have sharpened or cutting edges. They are designed to perform operations such as clamping, hammering, twisting, turning, tightening, pulling, etc.

b. Hammers.

(1) General. The machinist peen hammers are generally used by machine shop personnel and mechanics. Machinist's peen hammers are made in several styles; the most common used by mechanics being the ball peen hammer (C, fig 1). The ball peen hammer has a round ball-shaped head and is used for all general purpose work. They are classified according to the weight of the head without handle. Other types of hammers are shown in figures 1 and 2.

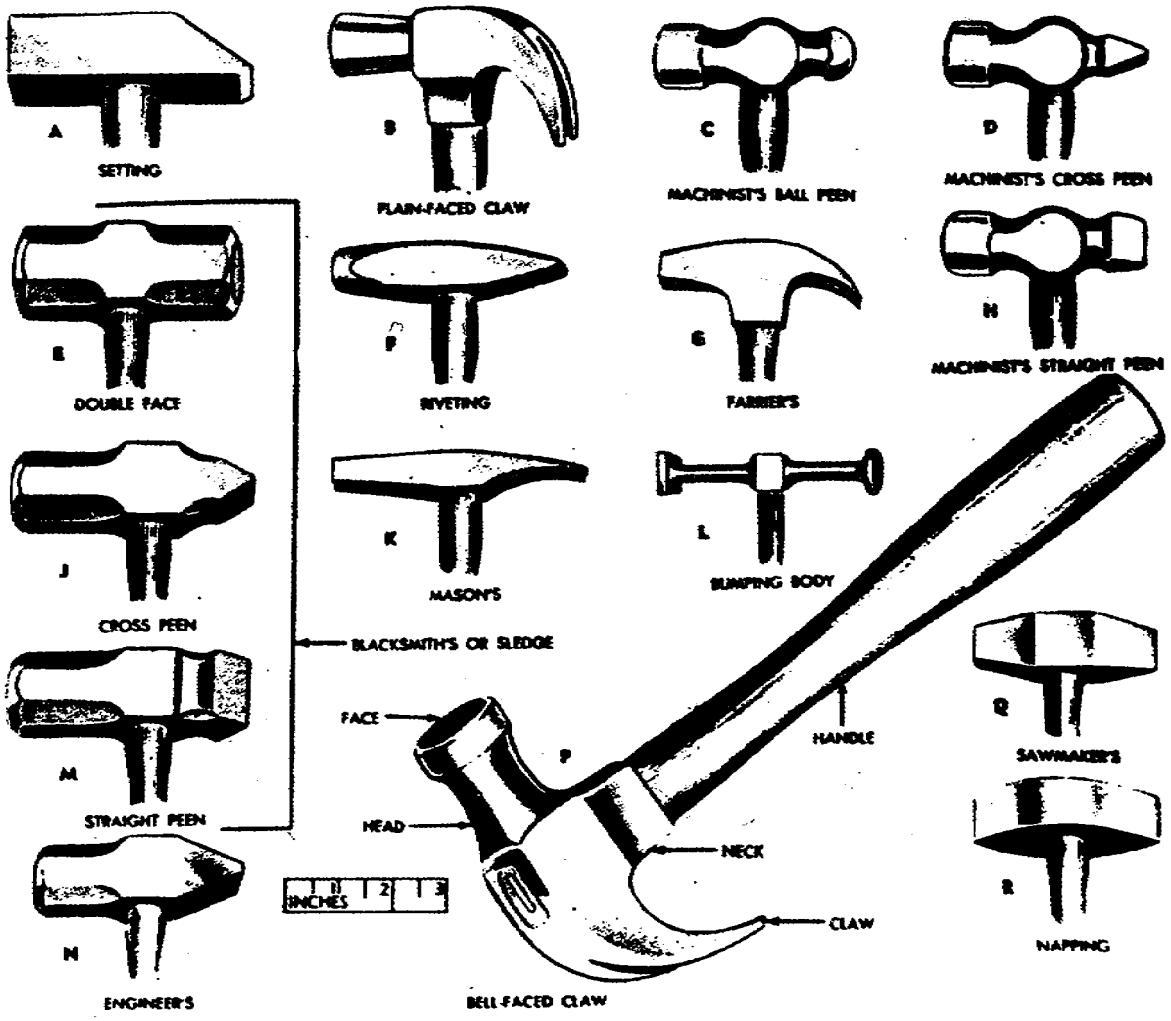


Figure 1. Types of hammers.

(2) Correct use of hammers.

(a) Simple as the hammer is, there is a right and wrong way of using it (fig 3). The most common fault is holding the handle too close to the head. This is known as choking the hammer and reduces the force of the blow. It also makes it harder to hold the head in an upright position. Except for light blows, hold the handle close to the end to increase the lever arm and produce a more effective blow. Try to hit the object with the full face of the hammer. Hold the hammer at such an angle that the face of the hammer and the surface of the object being hit will be parallel. This distributes the force of the blow over the full face and prevents damage to both the surface being struck and the face of the hammer.

(b) Never strike a hardened steel surface with a hammer. This misuse is a serious safety hazard. Small pieces of sharp, hardened steel may break from the hammer and also from the hardened steel. Besides causing damage to the work and/or the hammer, a serious eye injury may result.

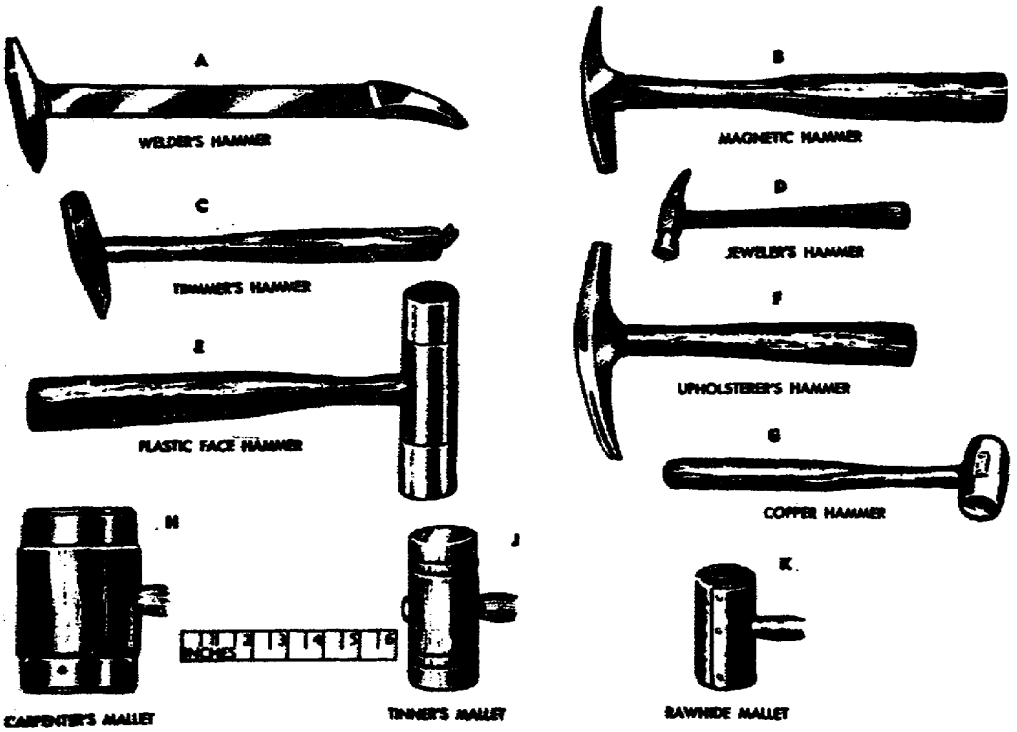


Figure 2. Mallets and hammers.

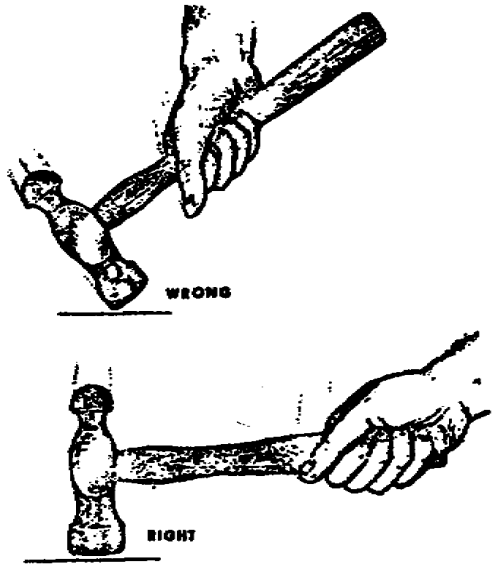


Figure 3. Right and wrong way to use a ball peen hammer.

(c) Do not use a hammer handle for bumping parts in assembly, and never use it as a pry bar. Such abuses will cause the handle to split, and a split handle can produce bad cuts or pinches. When a handle splits or cracks, do not try to repair it by binding with tape, string, or wire. Replace It.

(3) Maintenance of striking tools. Hammers, sledges, or mallets should be cleaned and repaired, if necessary, before they are stored. Hammer and sledge faces should be free from oil or other material that would cause the tool to glance off nails, spikes, or stakes. The hammer heads should be dressed to remove any battered edges. Inspect the handles of striking tools and make sure they are secure to the head and do not have any cracks or splinters. Never leave a wooden or rawhide mallet in the sun, as it will dry out and may cause the head to crack. A light film of oil should be left on the mallet to maintain a little moisture in the head.

c. Wrenches.

(1) Types. Wrenches are used to tighten or loosen nuts, bolts, screws, and pipe plugs, special wrenches are made to grip round stock, such as pipe, studs, and rods. Spanner wrenches are used to turn cover plates, rings, and couplings. There are many types of wrenches and each type is designed for a specific use.

(2) Fixed-end wrenches.

(a) Open end wrenches. Various open end wrenches are shown in figure 4. They are usually double ended wrenches although some have a single open end. These wrenches are forged from chrome vanadium steel and heat treated. The size of the opening between the jaws determines the size of the open end wrench. For example, a wrench with a 1/2-inch opening in one end and a 9/16-inch opening in the other end is called a 1/2 x 9/16 wrench. The size of each opening is usually stamped on the side of the wrench. The openings are from 0.005 inch to 0.015 inch larger than the size marked on the wrench so that they will easily slip on boltheads or nuts of that size. Open end wrenches are made in many different sizes. Wrench sizes range upward in steps of 1/32 inch, starting with 5/32 inch up to 1-3/4 inches. The common open end wrench is made with the ends at an angle of 10° to 23° to the body of the wrench so that the user can work in close quarters. Other special open end wrenches may have the ends at an angle of 45°, 60°, 75°, or 90°, or a combination of two angles. The length of the wrench is determined by the size of the opening since the lever advantage of the wrench is proportional to its length; wrenches with larger openings are made longer and heavier to increase leverage and strength.

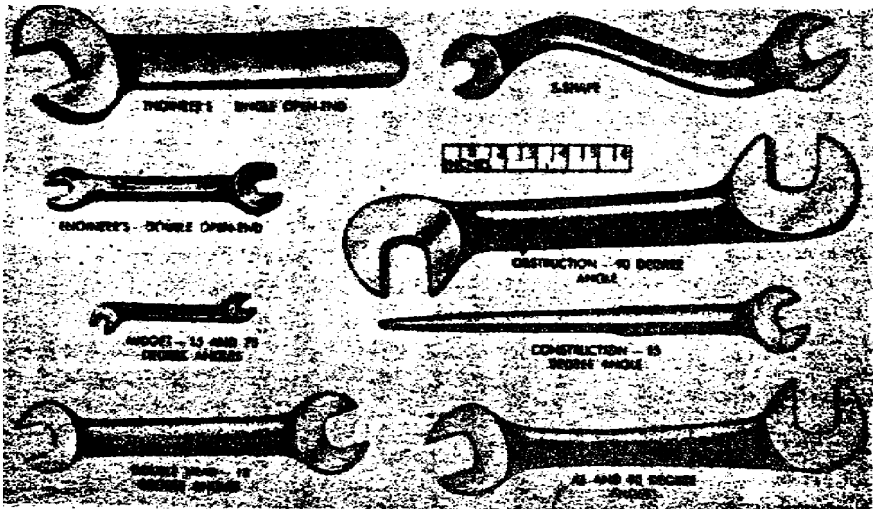


Figure 4. Open end wrenches.

(b) Box end wrenches. Box wrenches (fig 5) are so named because they completely surround or box the bolthead or nut. The opening in a box wrench contains 6 or 12 notches, called points, arranged in a circle. The box wrench is a safer tool than the open end wrench since it will not slip off the work. As little as one-twelfth of a turn can be taken at each stroke, if necessary, in close quarters. Box wrenches may have straight handles, they may be offset, or the box end may be offset. Box wrenches are available in the same sizes as are open end wrenches and usually have two openings: one opening, 1/16 inch larger than the other. Some openings may be 1/32 or 1/8 inch larger than the other. A ratchet box wrench usually has two 12-point openings and is not automatically reversible. However, it can be turned around to do both tightening and loosening operations. Being of sturdy, thin construction, they are convenient for working in limited spaces. Ratchet box wrenches are issued in four sizes ranging from 3/8 and 7/16-inch openings to 3/4 and 7/8-inch openings.

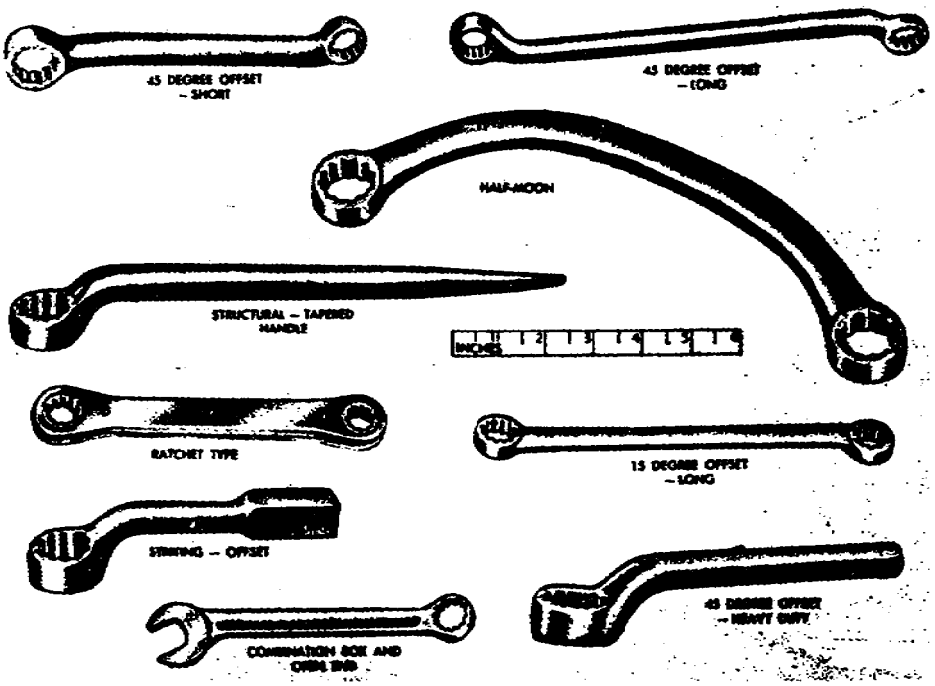


Figure 5. Box and combination wrenches.

(c) Combination open and box wrenches. Combination wrenches (fig 5) have one open end and a box wrench at the other end. Combination wrenches may be made with any combination of sizes, offsets, and angles as discussed above.

(d) Socket wrenches. The common socket wrench is boxlike and made as a detachable socket (fig 6) for various types of handles. A socket wrench set usually consists of various sized sockets, a ratchet (fig 7), sliding bar tee, speeder, speed tee, ratchet adapter, nut spinner, 3/8-inch drive handle, and extensions. Socket wrenches have two openings: one a square hole which fits the handles and the other a circular hole with notched sides to fit the bolt or screw head or nut to be turned. The square hole is made 1/4, 3/8, 1/2, 3/4, or 1 inch in diameter; each must be driven with the matching drive or speeder handle. The notched opening may have 6, 8, or 12 points. Socket wrenches are the fastest wrenches to use, since the ratchet handle permits the socket to remain on the nut or bolt and the handle does not have to be removed from the socket for turning. Socket wrenches are sized from 5/32 to 3-1/8 inches in steps of 32ds, 16ths, or 8ths of an inch.

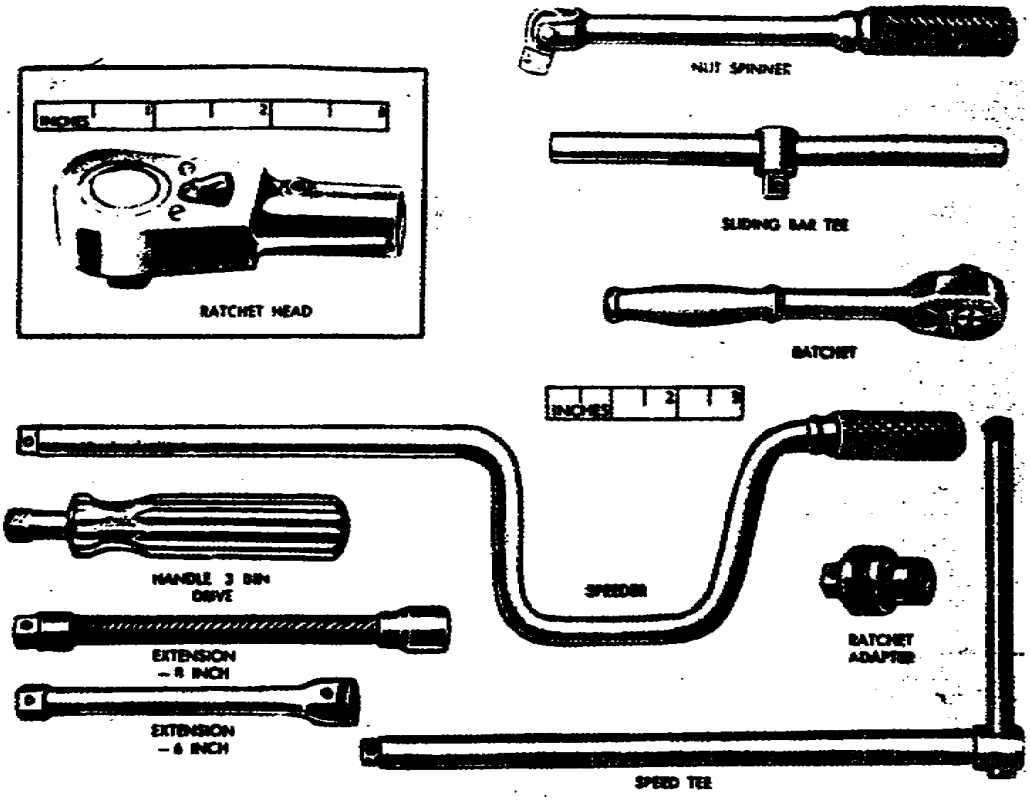


Figure 6. Socket and crowfoot wrenches.

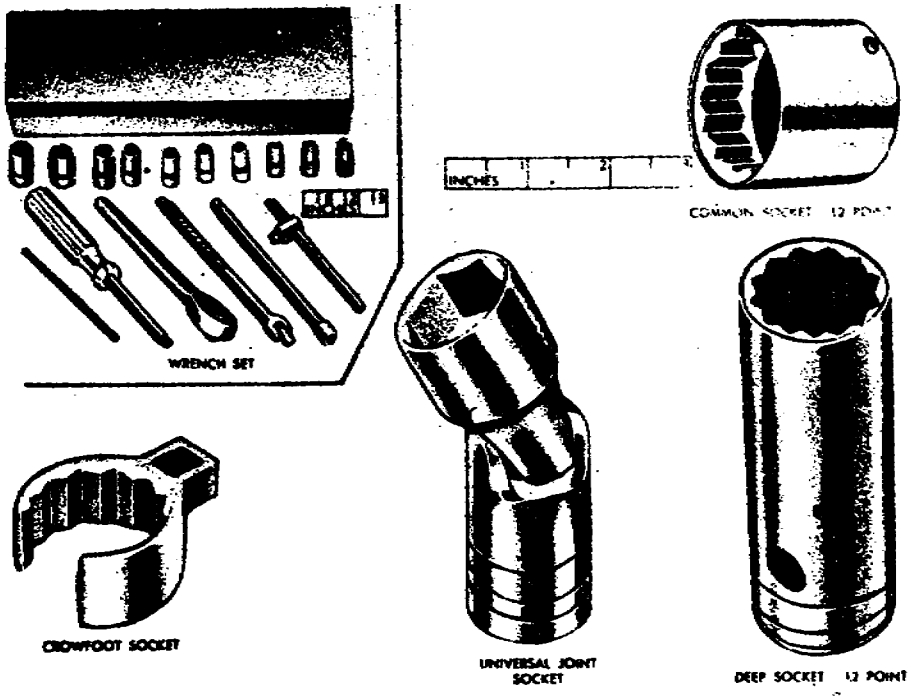


Figure 7. Socket wrench ratchets, handles and extensions.

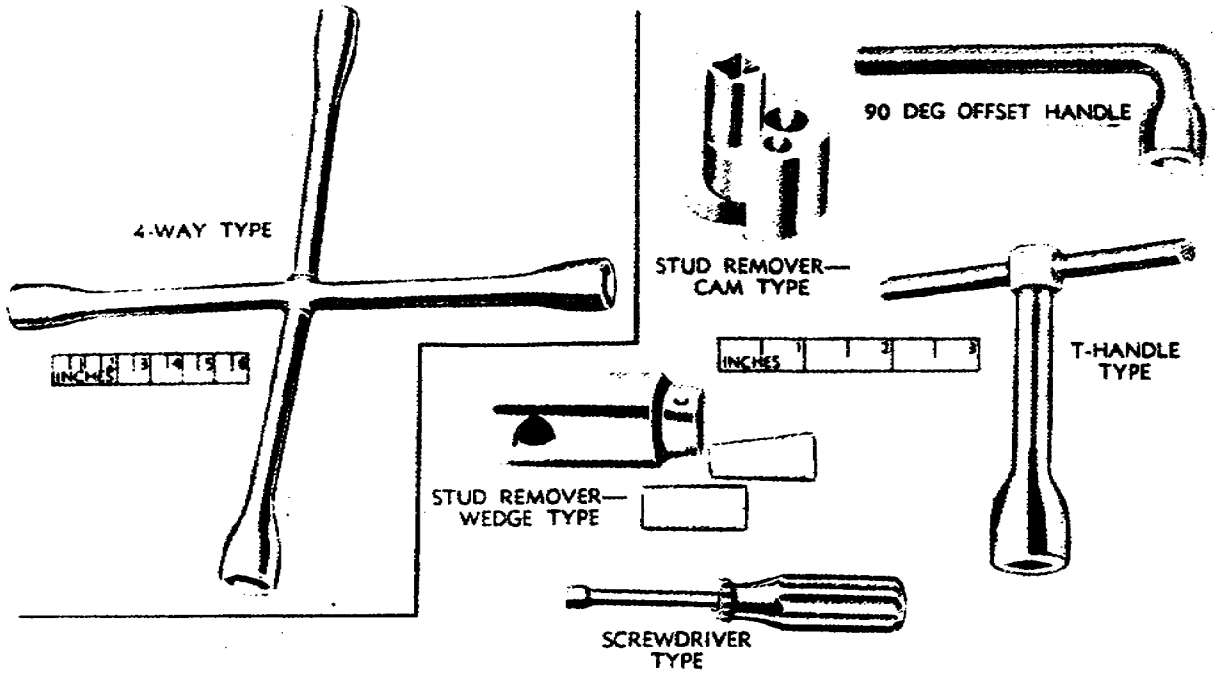


Figure 8. Special socket wrenches.

(e) Special socket wrenches. Some socket wrenches are not detachable and are of one-piece construction, such as the four-way socket wrench and the 90° offset handle shown in figure 8. Other socket wrenches are of the screwdriver type, having a six-pointed or a square socket. These may be straight or offset and have a T-type or regular screwdriver handle. Two types of stud remover sockets are available that are used with any 3/4-inch square drive socket wrench handle. One type has an eccentric cam which grips soft or hardened studs. The driving shank extends through both sides of the housing to provide a bearing surface on each side of the cam and prevent binding. The cam type has a capacity of 1/4 to 3/4 inch. The heavy-duty wedge-type stud remover socket works on the wedge principle and takes a positive grip which can be released only when the tool is turned in the reverse direction. Two sizes of steel wedges are included with the socket. This type has a capacity of 9/16 to 1 inch.

(f) Crowfoot wrenches. A crowfoot wrench (fig 6) has an open end in the box containing notches and a square hole which fits the handle. They are used in conjunction with the socket wrench handles having a 3/8- or 1/2-inch square drive. They range in size from 3/8 to 2-1/2 inches.

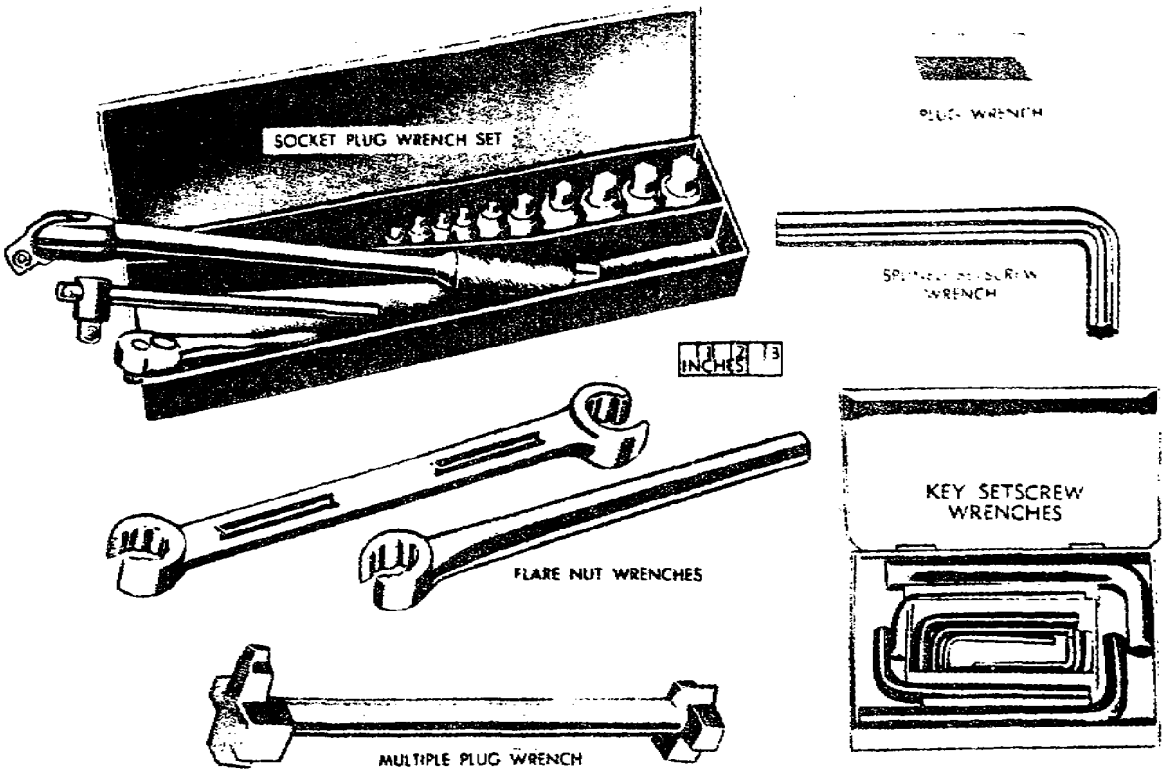


Figure 9. Setscrew, plug, and flare nut wrenches.

(g) Setscrew and hollow-head capscrew wrenches. Most setscrews and hollow-head capscrews have a hexagon (six-sided) socket. The commonly known key (Allen) wrench (fig 9) is L-shaped, is made of tool steel, and has a hexagonal or square section to fit these screws. Splined setscrew wrenches (fig 9) are made of round stock with ends to fit little flutes or splines in headless setscrews. A hollow-head capscrew set is also supplied. This set has detachable sockets which are used with the accompanying handles.

(h) Plug wrenches. A plug wrench is a straight bar having a hexagon or square shape and is available in a range of sizes from 3/8 to 1 inch in width. They are usually 2 inches long. Plug wrenches are also made to fit drain plugs of transmissions, differentials, and all types of gearcases. The multiple plug wrench is a combination type having several different size and shape ends. Most plug wrenches are made for a specific size plug. There are single-end plug wrenches that range in size from 3/16 to 11/16 inch with a hexagonal or square end. Double-end plug wrenches with square ends are issued for 3/8-and 1/2-inch plugs and 3/8- and 3/4-inch plugs. These wrenches are normally 8 to 12 inches long. Socket plug wrenches (fig 9) have a 1/2-inch square drive to be used with socket wrench handles.

(i) Flare nut wrenches. A flare nut wrench (fig 9) is a notched thin walled split box wrench especially designed to fit over nuts in very close places. It is ideal for tightening brass tube flare nuts. It grips the nut on five sides; thus, it does not slip and mar the nut. Flare nut wrenches are of 12-point design and have either a single or double end. Openings range in size from 3/4 to 1-5/8 inches.

(3) Adjustable wrenches.

(a) Singe open end wrench. The single open end adjustable wrench (fig 10) is similar in shape to the fixed end nonadjustable open end wrench, but has one adjustable jaw and one stationary jaw. The adjustable end wrenches issued have 1-3/8- to 2-7/8-inch jaw openings and are 24 inches long. A knurled nut is rotated to bring the movable jaw up to fit the nut or bolthead.

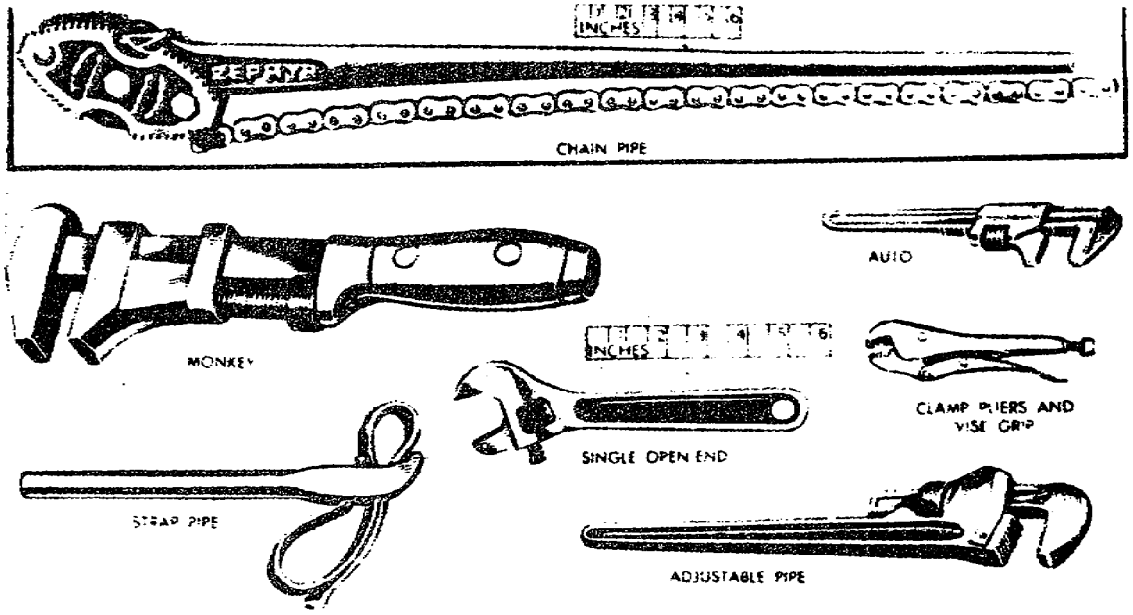


Figure 10. Adjustable wrenches.

(b) Auto and monkey wrenches. The auto and monkey wrenches (fig 10) are similar in design. They are of sturdy construction and are made to fit a wide range of nuts and bolts. They are designed principally for turning odd sized nuts or bolts which the open end, box, or socket wrenches will not fit and when work requires a sturdy wrench. They are supplied in several sizes from 5 to 21 inches long.

(c) Clamp pliers and vise grip wrench. The clamp pliers and vise grip wrench (fig 10) has one movable jaw and one stationary jaw. The movable jaw is adjusted by an adjusting screw in the base of the stationary jaw handle. The movable jaw can be clamped around a nut or bolt after setting the jaw to the de sired size. This type wrench is issued in two sizes: 1-1/8-inch jaw opening capacity and 7 inches long and 1-1/4-inch capacity and 10 inches long.

(4) Pipe wrenches.

(a) Adjustable pipe wrench. The adjustable pipe wrench (fig 10) has two jaws that are not parallel. The outer jaw, which is adjustable, is made with a small amount of play which provides a tight grip on the pipe when the wrench is turned in the direction of the movable jaw. This is the only wrench which will take a bite on round objects. The jaw always leaves marks on the work and should never be used on nuts or bolts unless the corners have been rounded so that you cannot turn it with another type of wrench.

(b) Strap pipe wrench. The strap pipe wrench (fig 10) is also used to turn cylindrical parts, but it will not mar the work because the strap serves as jaws. These wrenches are issued in a 1/8- to 2-inch pipe capacity size and a 1- to 5-inch pipe capacity size.

(c) Adjustable chain pipe wrench. The adjustable chain pipe wrench (fig 10) is a long handled tool with a single jaw and a length of chain that fits around the pipe to be turned and over the connection at the end of the jaw. The chain acts as the other jaw. It is used for gripping rough pipework on large diameter pipe. These wrenches range in size from 35 to 64 inches long and have a pipe capacity of from 3/4 inch to 12 inches.

(5) Torque wrenches. A torque wrench (fig 11) is used for work requiring a particular force (torque) to tighten bolts, nuts, capscrews, etc, to a desired degree of pressure. A dial or scale calibrated in foot-pounds indicates the degree of torque placed on the work. The pointer moves to the right or left of zero, depending on the bolt (left- or right-hand threads) being tightened. These wrenches are issued in several sizes. They may have a 1/4-, 1/2-, or 3/4-inch square drive to receive socket wrenches and the capacity may range up to 600 foot-pounds.

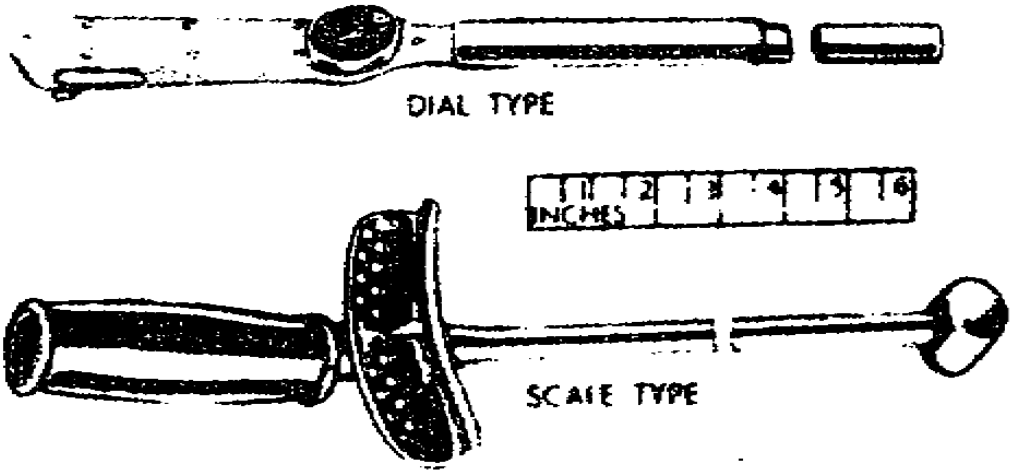


Figure 11. Torque wrenches.

(6) Spanner wrenches.

(a) Fixed spanner wrenches. Fixed spanner wrenches (fig 12) are used to turn flush type and recessed retaining rings, cover plates, plugs, hose couplings, and parts which have holes or slots for insertion of the wrench pins or lugs. Each of this type spanner wrench is designed for a particular job.

(b) Adjustable spanner wrenches. An adjustable face spanner wrench (fig 12) has two legs joined together with a pivot pin. The legs can be opened and closed, thus allowing the pins at the end of the legs to fit the various distances between holes found in many types of cover plates and plugs. Another type of adjustable spanner wrench is shaped like a hook, called an adjustable hook spanner wrench. The position of the hook can be adjusted to fit different size couplings and other parts.

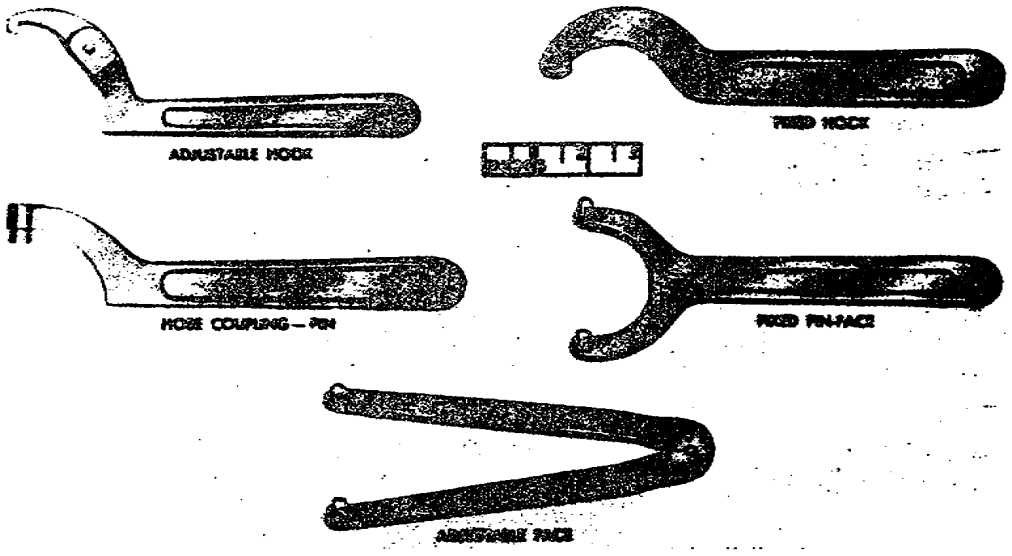


Figure 12. Spanner wrenches.

(7) Using wrenches.

(a) Open end wrenches. It is important for a wrench to be a snug fit on a nut or bolthead. If it is too loose, the wrench will slip and round the corners. Make certain that the wrench fits squarely on the sides of the nut or bolthead (fig 13 and 14). Offset open-end wrenches make it possible to turn a nut or bolt that is recessed and in limited quarters where there is little space to swing the wrench. Turn the wrench over after each swing so that the opposite face is down and the angle of the wrench opening is reversed (fig 14). Always place yourself so that you can pull on the wrench to turn the work in the desired direction.

CAUTION: Do not push on a wrench; if the wrench slips or the bolt breaks loose suddenly, you may skin your knuckles and be thrown off balance.

There are times, however, when the only way you can move the wrench is by pushing it. In this case, do not wrap your fingers around it. Push it with the palm of your hand and hold your hand open.

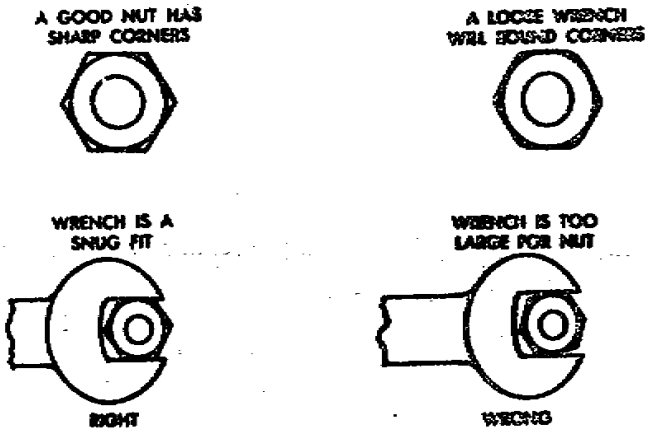


Figure 13. Fitting open end wrench.

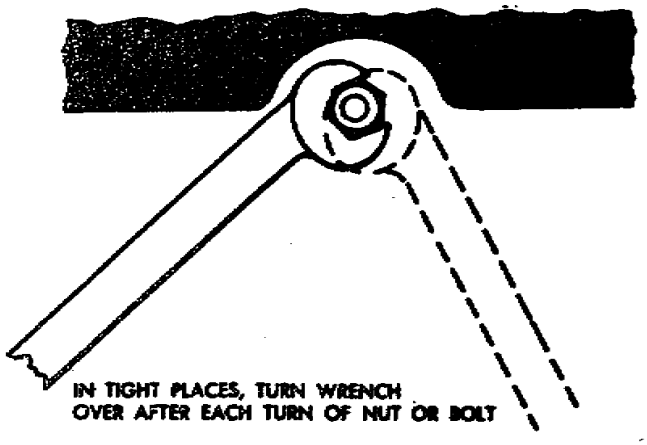


Figure 14. Use of open end wrench.

(b) Box wrench. Always select the size of wrench that fits the nut or bolthead. Box wrenches will not slip off and are preferably used before open end wrenches. A swing through an arc of 15° is sufficient to continuously loosen or tighten a nut or bolt. Unless there is room to swing a box wrench in a full circle, lift it completely off the nut when it comes to the limit of its swing and place it in a new position which will permit it to be swung again. Since a box wrench cannot slip off a nut, it is ideal for loosening tight nuts and bolts and for setting them up. To set up means to give already tight nuts or bolts their final tightening. After a nut is started, it can usually be worked more quickly with an open end wrench than with a box wrench. For this reason, combination box and open end wrenches are very popular and more convenient-the box end to break loose or set up and the open end to do the actual turning.

(c) Socket wrenches. To use a socket wrench, select the size of socket that fits the nut or bolt to be turned and push it onto the handle which is best suited to the job. If there is room to swing it, use the ratchet handle. The handle may be made to ratchet in one direction for tightening and in the other direction for loosening work. It is necessary only to swing the handle back and forth in order to turn the nut in the desired direction. The socket need not be raised from the nut at the end of each swing. A nut spinner handle (fig 7) also saves time. When a tight nut is to be loosened or a nut is to be set up, the handle can be swung at right angles to the socket to provide the most leverage. At the point where the nut turns easily, the handle can be swung to a vertical position and twisted rapidly between the fingers in the same manner as a screwdriver. A universal joint socket wrench (fig 6) makes it possible to turn nuts where a straight wrench could not be used unless some part of the machine or equipment is removed.

(d) Key (Allen) setscrew wrenches. Select the proper type and size that fits the recess of the screw being worked on. The short end of the wrench is used to give a final tightening or break loose tight screws. The long end of the wrench is used to turn the screw rapidly when very little leverage is needed.

(e) Adjustable open end wrench. Always place the wrench on a nut or bolt so that the force used to turn it is applied to the stationary jaw side of the wrench (fig 15). After placing the wrench in position, tighten the knurled adjusting nut until the wrench fits the nut or bolthead as tightly as possible. If it does not fit tightly, it will slip, which may result in an injury to your hand and may also round the corners of the nut or bolthead.

(f) Auto and monkey wrenches. Use the auto or monkey wrench in the same manner as you would the adjustable open-end wrench.

Note. - Always place the wrench on a nut or bolt so that the turning force is applied to the back of the handle; that is, the side of the wrench opposite the jaw opening (fig 15).

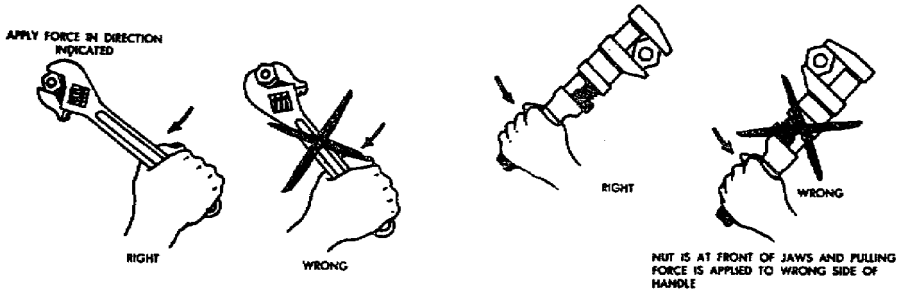

APPLY FORCE IN DIRECTION INDICATED
RIGHT
WRONG
RIGHT
WRONG
NUT IS AT FRONT OF JAWS AND PULLING FORCE IS APPLIED TO WRONG SIDE OF HANDLE

Figure 15. Using adjustable wrenches.

(g) Pipe wrenches.

1. Adjustable pipe wrench. The adjustable pipe wrench will work in one direction only. Always turn the wrench in the direction of the opening of the jaws. Apply force to the back of the handle. Since the top jaw is capable of a slight angular movement, the grip on the work is increased by pressure on the handle (fig 16).

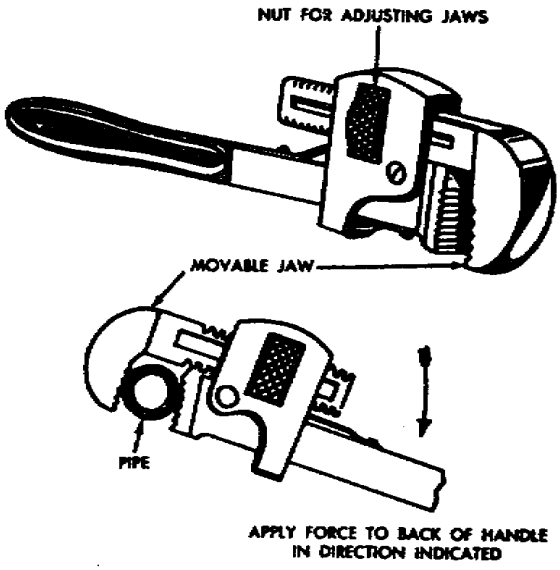


Figure 16. Using adjustable pipe wrench.

2. Adjustable strap pipe wrench. When using the adjustable strap pipe wrench, loop the strap around the pipe in the opposite direction to that in which the pipe is to be rotated (fig 17). Slip the end of the strap through the shackle and draw it up tightly. Pull the handle to turn the pipe in the desired direction. The jaw at the end of the shackle will seat against the strap and, as the handle is pulled, the strap will tighten and turn the pipe.

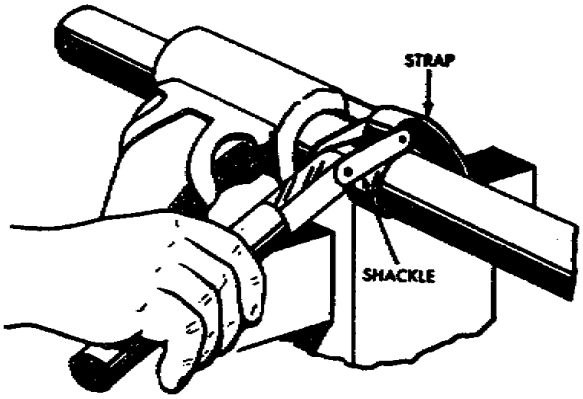


Figure 17. Using a strap pipe wrench.

3. Adjustable chain pipe wrench. The adjustable chain pipe wrench is used in the same manner as the strap wrench. The chain acts as a jaw, when looped around the pipe, gripping the pipe on the entire outer circumference. It is used for rough pipework on very large diameter pipe.

(h) Torque wrench. A torque wrench enables you to set up a nut or bolt when the force applied to the handle reaches the specified limit. Manufacturers' instructions specify these limits of turning force. Cylinder head nuts and bolts, rod bearing caps, and other places on automotive and airplane engines usually require torque wrench limits. Select proper size socket wrench and attach to torque wrench square drive. Place socket wrench on work and pull the torque wrench handle in the desired direction to tighten the work. The tightening torque will be indicated on the dial or scale, depending on the type of the torque wrench used.

(i) Spanner wrench. When using a pin-face spanner wrench (fig 18), insert the pins or lugs into the pinholes of the part. Keep the pin face of the wrench flush with the part surface and turn the wrench. Exert enough force against the wrench so that the pins do not jump out of the holes. Hose coupling spanner wrenches are shaped so that they fit around the coupling with the pin or lug at right angles to the handle. Insert the pin in the hose coupling pinhole. Pull or push the handle in the direction opposite the hook of the spanner wrench. Make certain the pin fits the hole and the force is applied with the handle perpendicular to the work. Use of an adjustable spanner wrench is shown in figure 19.

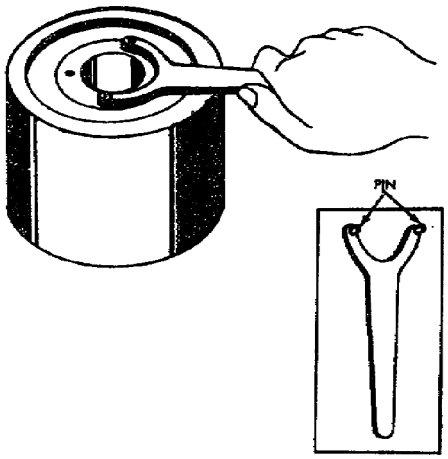


Figure 18. Using a pin-face spanner wrench.

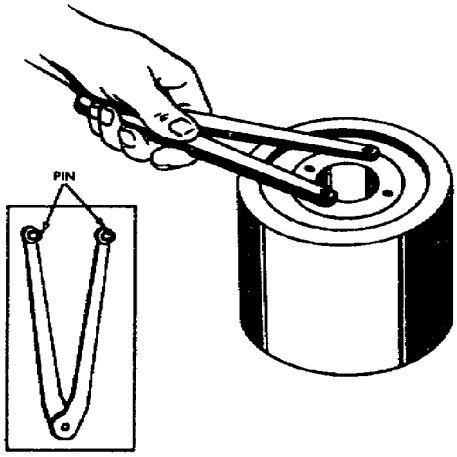


Figure 19. Using adjustable spanner wrench.

(2) Care and maintenance. Clean all wrenches after use. Apply a thin film of oil to metal parts of all wrenches prior to storing. Wrenches that come in sets, such as socket wrenches, should be returned to their cases after being used. The torque wrench, in particular, must be carefully placed in its box to prevent damage to the dial or scale. For long periods of storage, the wrenches should be covered with a rust-preventive compound and carefully stored in a dry place.

d. Screwdrivers. These are used for driving or removing screws or bolts with slotted or special heads and are made in various shapes and lengths to perform specific jobs. The size of a screwdriver (fig 20) is indicated by the length of the blade; i.e.; a 6-inch screwdriver has a 6-inch blade. The width and shape of blade tips vary from a narrow parallel sided tip to a wide tapered tip. Some screwdrivers have special tips for cross-slotted recessed screws or bolts and clutch-bit screws. Special screwdrivers are provided with a ratchet arrangement.

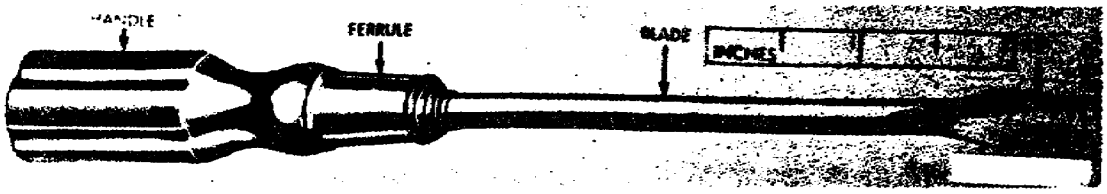


Figure 20. Standard screwdriver.

(1) Common screwdriver. The common screwdriver (fig 21) has a round steel blade anchored in a wood or plastic handle. The blade is forged from alloy steel and tempered. The tip is flat, hot forged to size, and heat treated. Common screwdrivers are tapered to give maximum strength. Handles are made of hardwood or plastic composition, usually fluted for a good grip. The blade is anchored in the handle by two or more tongs on the end of the blade, and in the case of a wood handle by a pin or rivet through the ferrule, handle, and blade. Some handles are integral; that is, the blade forms an integral part of some of the outside surface of the handle and is locked in place by rivets. Integral blade screwdrivers are used for heavy-duty work. The blade can be tapped with a hammer to seat the blade tip in rusty screws. Other common heavy-duty screwdrivers have square blades so that a wrench can be used to turn them.

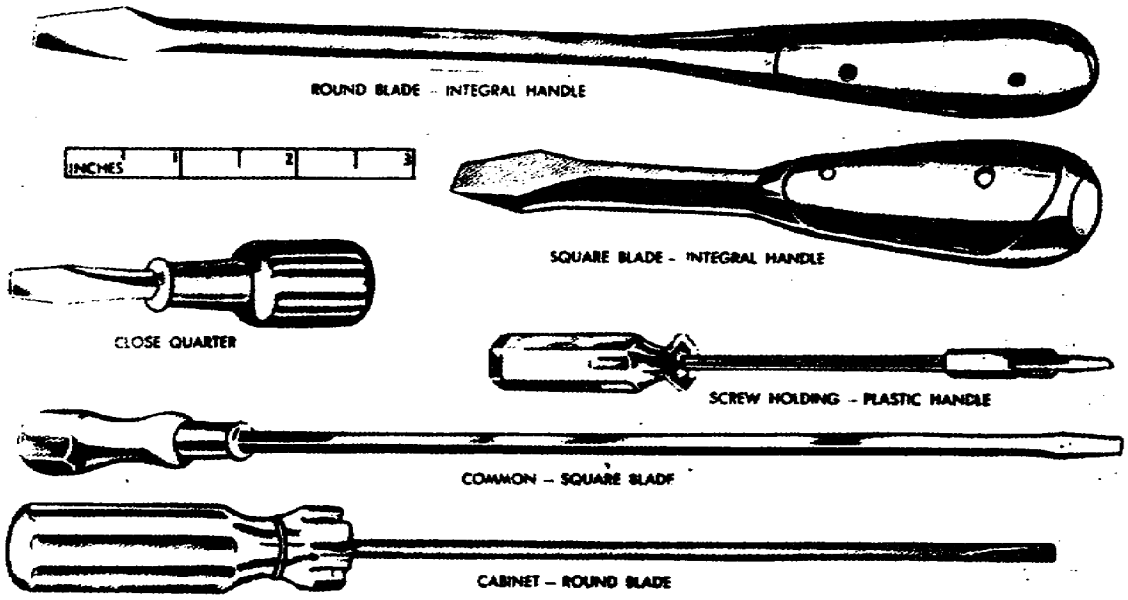


Figure 21. Common, flat-tip screwdrivers.

(2) Phillips screwdrivers (cross-tip). The tip of a Phillips screwdriver (fig 22) is shaped like a cross so that it fits into Phillips-head screws. Phillips-head screws have two slots which cross at the center. These screwdrivers are made with four different sized tips. Size 1 will fit No 4 and smaller size Phillips screws; size 2 will fit No 5 to 9 inclusive; size 3 will fit No 10 to 16 inclusive; and size 4 will fit No 18 and larger sizes. Phillips screwdrivers also have different length blades ranging from 1 inch to 8 inches.

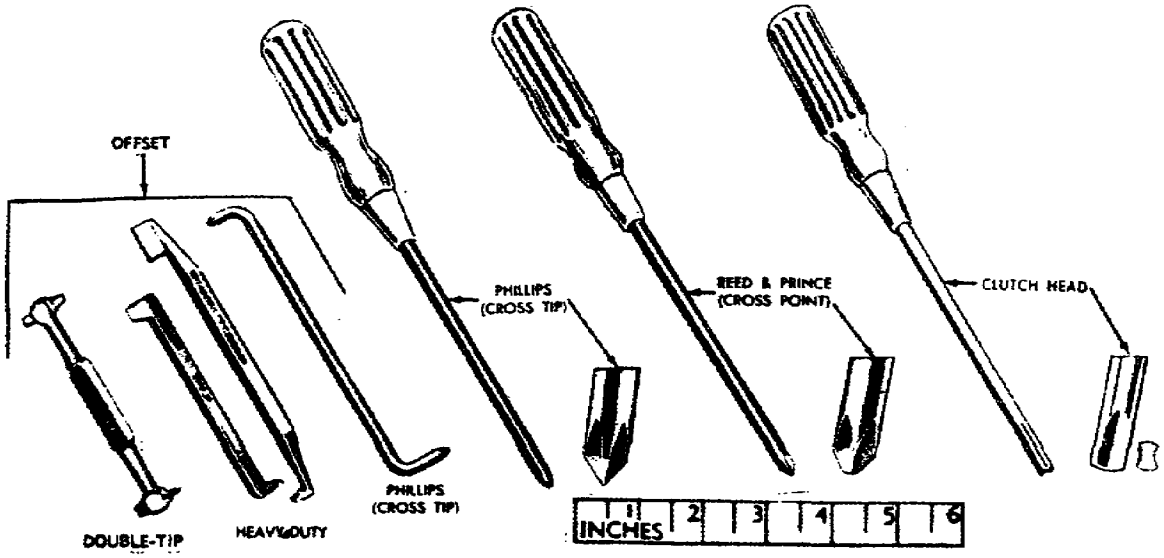


Figure 22. Special tipped screwdrivers.

(3) Reed and Prince screwdrivers (cross-point). Reed and Prince screwdrivers are similar to the Phillips type; however, do not confuse them for the tip is different, as shown in figure 22. These screwdrivers are issued in 3- to 8-inch sizes.

(4) Clutch-head screwdrivers. Clutch-head screwdrivers (fig 22) are used to drive clutch-bit screws. These screws are commonly called butterfly or figure 8 screws and have recessed heads. The clutch-type screwdriver is issued in 3-, 4-, 5-, and 6-inch sizes.

(5) Offset screwdrivers. Offset screwdrivers (fig 22) are designed to drive or remove screws that cannot be lined up with the axis of common screwdrivers or are located in tight corners. An offset screwdriver is usually made from a piece of steel, round or octagonal in shape, machined so that the end portion is at right angles to its longitudinal axis. They are made in a variety of sizes having different width tips. Some offset screwdrivers are made with two blades, one of different size at each end. A doubletip offset screwdriver has four blades.

(6) Ratchet screwdrivers. Ratchet screwdrivers (fig 23) are used to drive or remove small screws rapidly. The spiral ratchet screwdriver automatically drives or removes screws. It can be adjusted to turn left, right, or locked to act as a common screwdriver. It has a knurled sleeve with a spiral chuck and a control locking device which has three positions: right and left ratchet and rigid. Some spiral ratchets have a spring in the handle which automatically returns the handle for the next stroke. Another style of ratchet screwdriver has a knurled collar for rotating the blade with your fingers. The spiral type has separate blades that are inserted in the chuck. The plain common ratchet screwdriver is made with one integrally built blade.

(7) Screwdriver bits. A screwdriver bit (fig 23) is a screwdriver blade with a square, hex, or notched shank so that it will fit in the chuck of a breast drill or ratchet bit brace, or on a square drive tool such as a socket wrench handle. Other screwdriver bits are made with a spiral ratchet screwdriver shank for use with spiral ratchets.

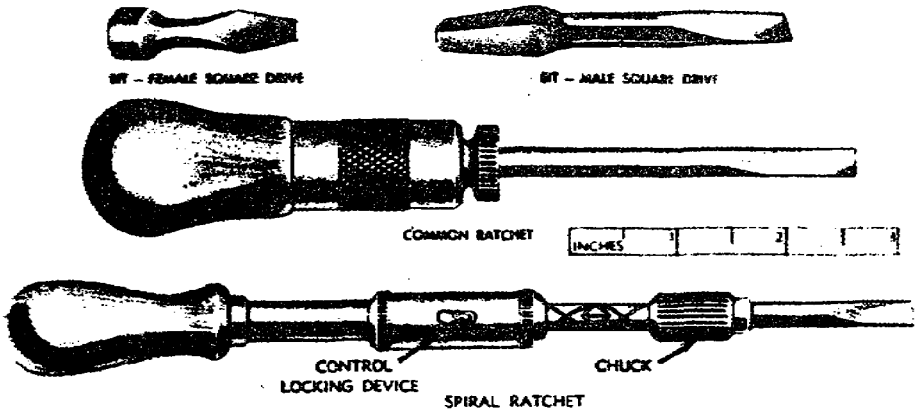


Figure 23. Ratchet screwdrivers and screwdriver bits.

(8) Using a screwdriver.

(a) Driving screws. Use the longest screwdriver available which is convenient for the work. The width of the tip should equal the length of the screw slot and the tip must be thick enough to fit the width of the screw slot (fig 24). Hold the handle firmly in one hand with the head of the handle against the palm and grasp the handle near the ferrule with your thumb and finger (fig 25). Hold the screwdriver in line with the axis of the screw and center the tip in the screw slot. To drive screw in, press down with your palm and turn the screwdriver clockwise (to the right). When taking a fresh grip on the handle, steady the tip and keep it pressed in the screw slot with your other hand. Relax your other hand when you are ready to turn the screwdriver again. To drive screws easier, rub a little soap into the threads of a wood screw and put a drop of oil or a little graphite on a machine screw. Doing this will also minimize the chances of rust forming on the screws and will make them easier to remove.

(b) Removing tight screws. When a screw cannot be turned at the first attempt to remove it, try to tighten it first, then turn the screwdriver opposite. Sequentially, tighten and loosen the screw until completely removed. If a tight screw with a damaged slot can be backed out partially, it is possible to remove it completely with a pair of pliers.

(9) Care of screwdrivers.

(a) Dressing and shaping. When a screwdriver becomes nicked, or the edges become rounded, or when other damage occurs so that it does not fit a screw slot, it must be reground or filed. The sides must be parallel to keep the tool from lifting from the screw slot, and the tip must be square and at right angles to the sides and to the blade. If using a file, place the screwdriver in a vise. When using a grinder, adjust the rest to hold the screwdriver against the wheel to produce the desired shape, parallel or concave. Do not grind away more material than necessary to remove nicks or square up the end. After squaring the tip, grind both sides until the tip is the required thickness. Dip the screwdriver into water frequently during grinding to prevent loss of temper by overheating. If the blade discolors {blue or yellow), the temper has been damaged. Retemper by heating about 1-1/2 inches of blade to a cherry red with a torch. Immediately dip about 3/4 inch of the blade in clean cold water. Quickly rub the hardened end with aluminum oxide abrasive to brighten it. Watch the color creep back into the tip from the heated portion of the blade. When the color becomes light blue, dip the blade into water. The tip is now retempered and ready for use.

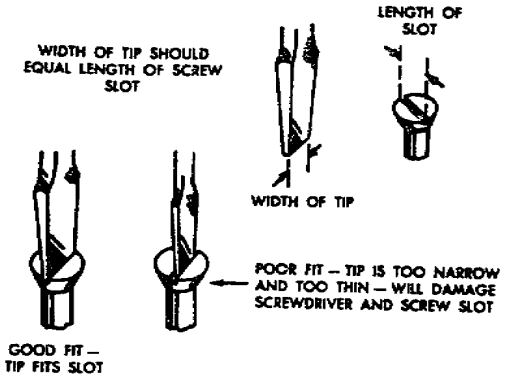

WIDTH OF TIP SHOULD EQUAL LENGTH OF SCREW SLOT
LENGTH OF SLOT
WIDTH OF TIP
POOR FIT – TIP IS TOO NARROW AND TOO THIN – WILL DAMAGE SCREWDRIVER AND SCREW SLOT
GOOD FIT – TIP FITS SLOT

Figure 24. Proper blade for specific screw.

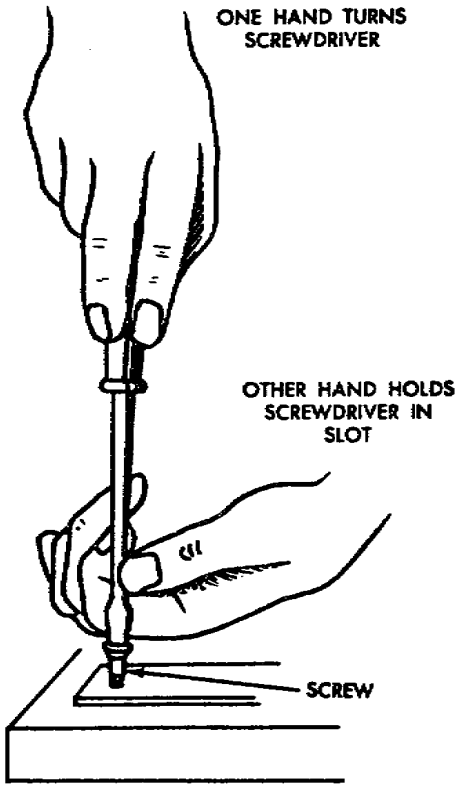


Figure 25. Holding screwdriver properly.

(b) Precautions. Handle the screwdriver carefully. Use the right sized screwdriver for the job. Keep the blade clean. Do not carry a screwdriver in your pocket unless it has a pocket clip. Never use a screwdriver for prying or chiseling operations. When difficulty is encountered in driving or removing screws that are hard to turn, do not use pliers to turn the screwdriver. Pliers will damage the screwdriver. For hard to turn screws, select a square bladed screwdriver designed for heavy duty, and a wrench which properly fits the blade.

(c) Storage. After use, wipe the screwdriver with light oil and place in a rack or toolbox.

e. Pliers. Pliers are used for gripping, cutting, bending, forming, or holding work and for special jobs. Tongs look like long-handled pliers and are mainly used for holding or handling hot pieces of metal work to be forged or quenched, or hot pieces of glass. Pliers basically consist of a pair of jaws designed for a specific purpose, a pivot or hinge, and a pair of handles. They are made in many shapes and sizes to handle a variety of jobs. The size is determined by the overall length, which usually is 5 to 10 inches.

(1) Types of pliers.

(a] Slip joint combination pliers. The slip joint combination pliers (fig 26) are most commonly used to hold or bend wires, small bars, and a wide variety of miscellaneous items. Some have short cutting edges near the hinge for cutting wire. The slip joint permits adjustment and wider opening of the jaws. The jaws have serrations or teeth for gripping.

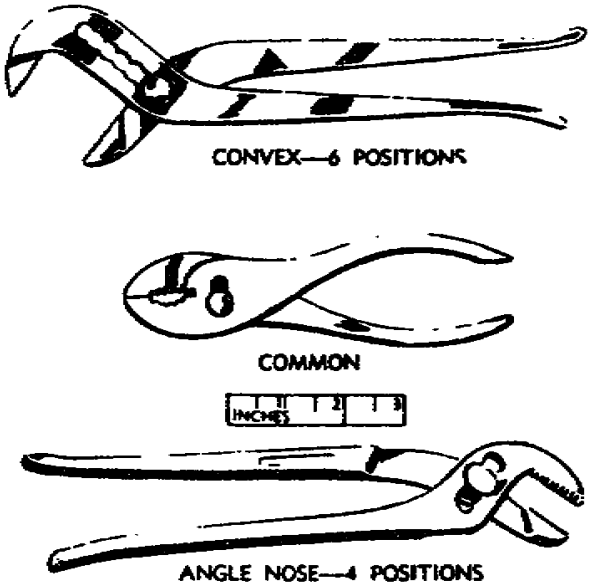


Figure 26. Slip joint combination pliers.

(b) Diagonal cutting pliers. Diagonal cutting pliers (fig 27) have short jaws with the cutting edges at a slight angle. They are used for cutting soft wire and stock and for removing cotter pins. They are also used for cutting cotter pins to desired length and for spreading the ends after the pin is inserted through a hole.

(c) Lineman's side cutting pliers. Lineman's side cutting pliers (fig 27) are for cutting wire and peeling insulation. The flat serrated jaws are also used to twist wire ends together in making splices.

(d) Parallel jaws, flat, and roundnose pliers. These pliers (fig 28) are used to bend or form metal into various shapes and to work in limited spaces. The nose is made in variety of widths and lengths. The parallel jaws pliers are supplied with or without side cutters.

(e) Special purpose pliers. Some pliers are made for specific jobs such as the brake spring pliers, glass holding and breaking pliers, ignition pliers, battery terminal pliers, and brake key and snapring pliers (fig 29).

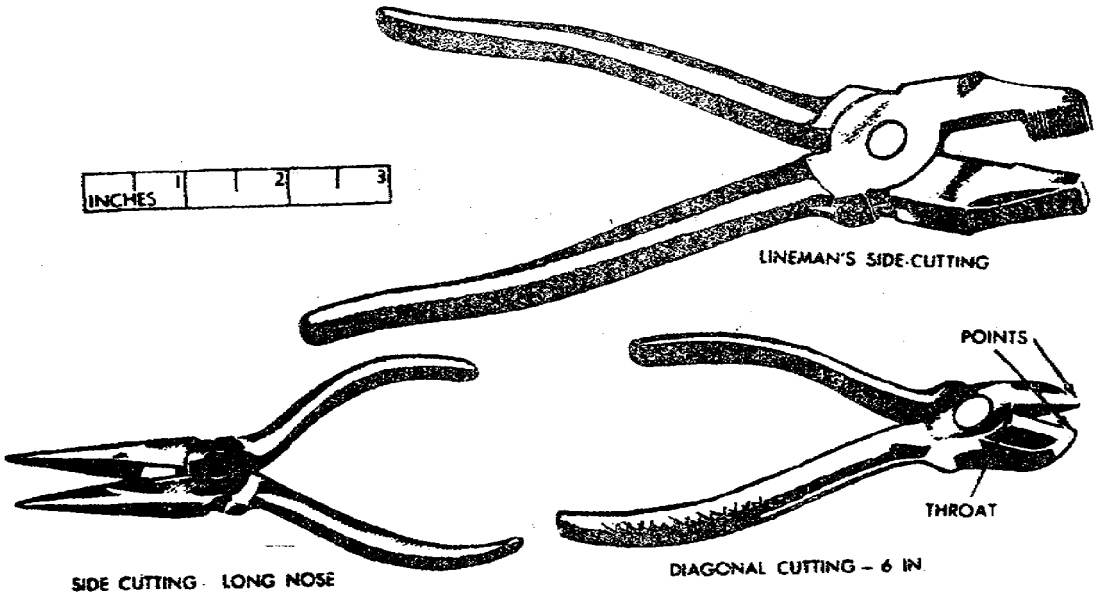


Figure 27. Diagonal and side cutting pliers.

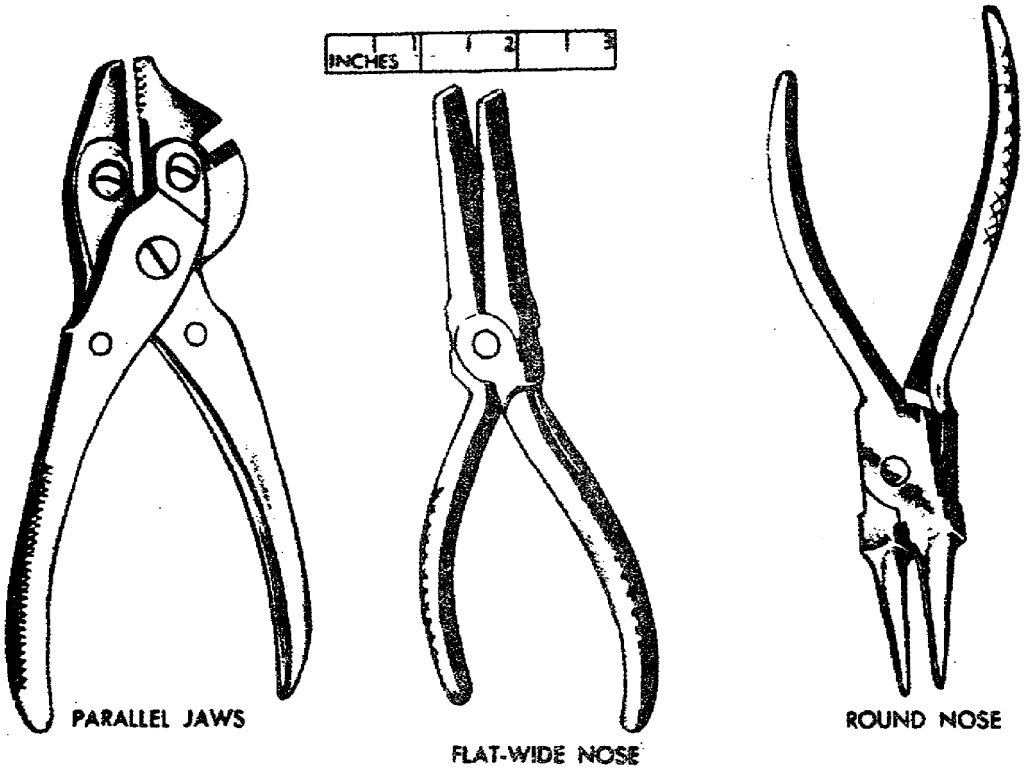


Figure 28. Parallel jaws, flat, and roundnose pliers.

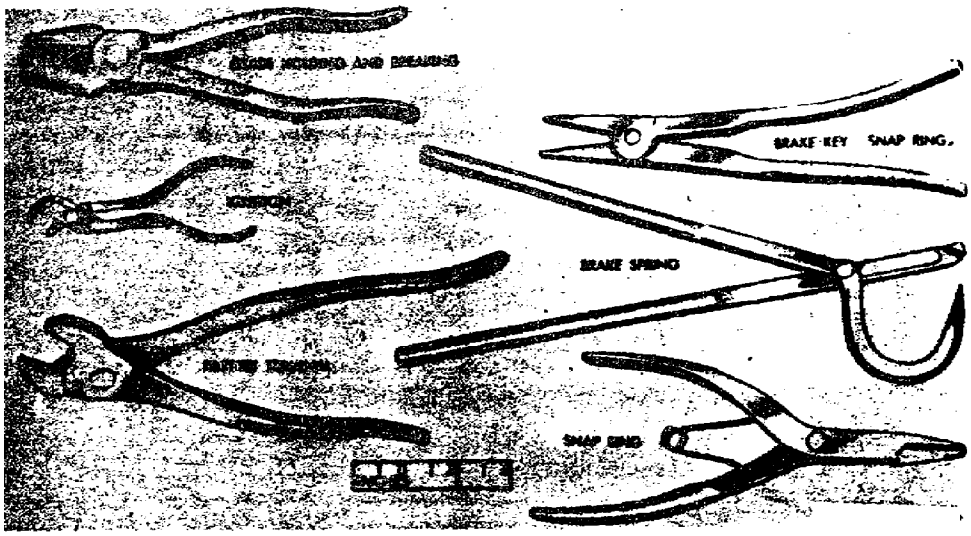


Figure 29. Special purpose pliers.

(2) Use of pliers. When using pliers, keep your fingers away from the jaws and cutting edges. Make sure the hinge or joint is tight before using pliers. Insulate handles of pliers when using them in electrical work with several thicknesses of friction tape, rubber tape, or specially manufactured rubber grips. When cutting large material within the capacity of diagonal cutting pliers, cut with the throat of the jaws, not with the points. The tendency of misalining the jaws will be greatly reduced. Once the jaws are misalined (sprung), it will be impossible to cut fine wire. To preserve the life of slip joint combination pliers, do not use them on very hard metal. Hard metal will wear off the teeth and the pliers will lose their grip. Use pliers only for the purpose for which they are intended. Do not try to increase the leverage of their handles by lengthening them with sections of pipe or other extensions.

f. Vises. Vises are used for holding work when it is being planed, sawed, drilled, shaped, sharpened, riveted, or when wood is being glued.

(1) Types of vises.

(a) Machinist's bench vise. A machinist's bench vise (fig 30) is a large steel vise with rough jaws that prevent the work from slipping. Most of these vises have a swivel base with jaws that can be rotated, while others cannot be rotated. A similar light-duty model is equipped with a cutoff. These vises are usually bolt-mounted onto a bench.

(b) Bench and pipe vise. The bench and pipe vise (fig 30) has integral pipe jaws for holding pipe from 3/4 inch to 3 inches in diameter. The maximum working main jaw opening is usually 5 inches, having a jaw width of 4 to 5 inches. The base can be swiveled to any position and locked. These vises are equipped with an anvil and are also bolted onto a workbench.

(c) Clamp base bench vises. The clamp base bench vise (fig 30) usually has a smaller holding capacity than the machinist's or bench and pipe vises and is clamped to the edge of a bench. Holding capacity is generally 1-1/2 to 3 inches. These vises normally do not have pipe holding jaws.

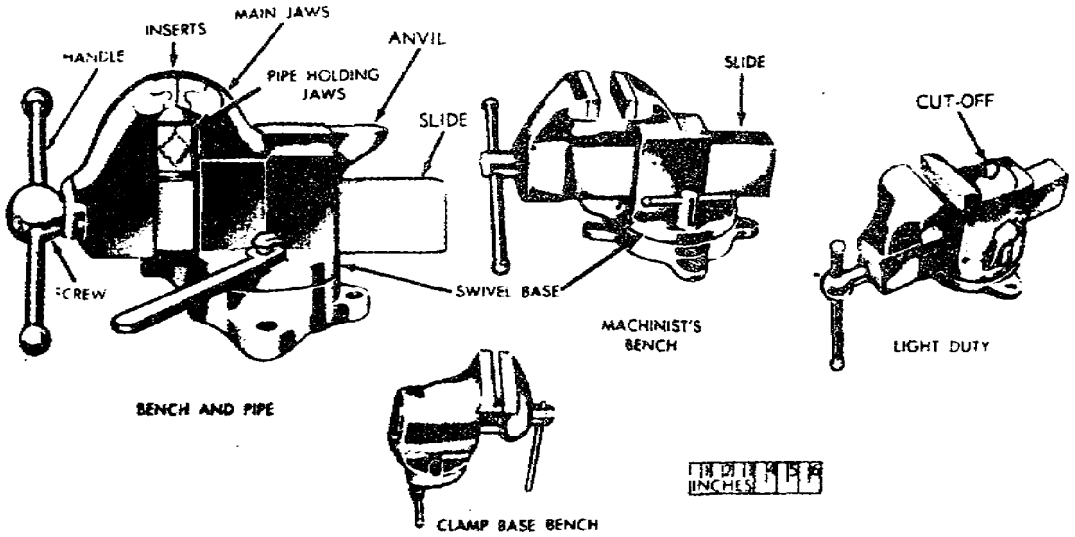


Figure 30. Types of vises.

(e) Pipe vises. A pipe vise (fig 31) is specifically designed to hold round stock. The vise shown has a capacity of 1 to 3 inches. One jaw is hinged so that the work can be positioned and then the jaw brought down and locked. This vise is also used on a bench. Some pipe vises are designed to use a section of chain to hold down the work. Chain pipe vises range in size from 1/8 to 2-1/2-inch pipe capacity up to 1/2 to 8-inch pipe capacity.

(f) Machine table vise. The machine table vise (fig 32) is constructed so that it may be secured on a machine table and work held for subsequent machining operations. These vises either have a 3-1/2-inch jaw width and a 3-inch jaw opening, or a 6-inch jaw width with a 6-inch jaw opening.

(g) Pin vise. A pin vise (fig 32) is held in the hand. Its overall length is usually about 4 inches. It has a chuck-type jaw which is capable of holding small stock from 0 to 0.187 inch in diameter.

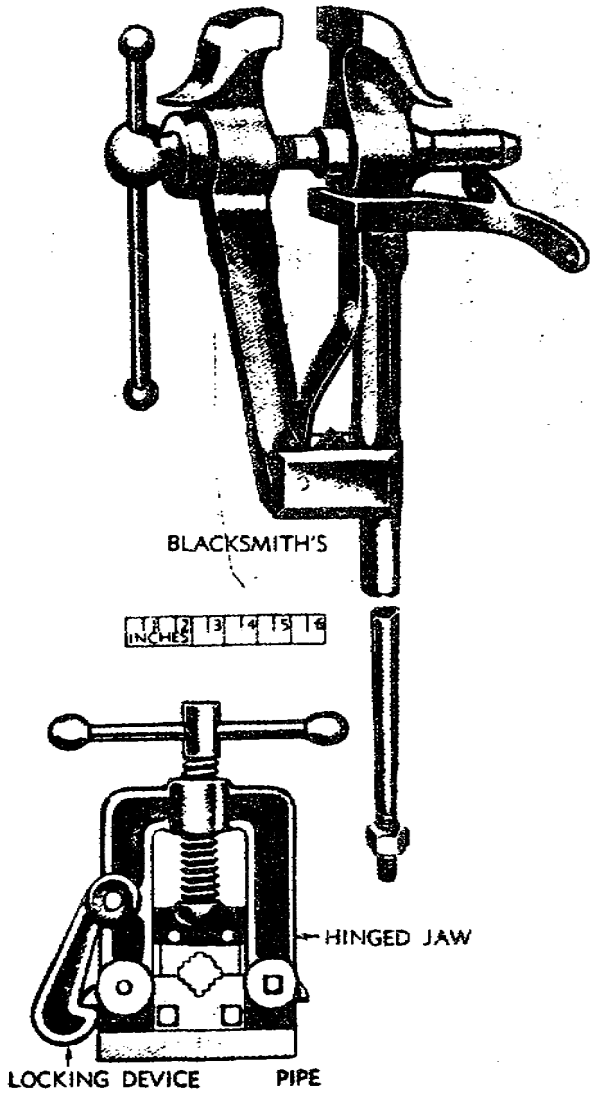
(2) Use of vises.

(a) When holding soft metal in a vise, material softer than the workpiece must be used in the jaws to prevent damage to the work. The work should be held securely to prevent it from slipping but not so tight that it will damage the work.

(b) When holding hard material, turn the screw of the vise up tight and tap the end of the handle sharply for the final tightening.

(c) To hold irregularly shaped work in a vise requires a little thought. Make certain the jaws grip on a firm even surface of the work. The swivel jaw type of vise (not illustrated) is especially suited to hold tapered or irregular work, since one jaw can be swiveled. A tapered pin must be removed before the jaw can be swiveled.

(d) Cylindrical work can be held between straight jaws; however, it is better to insert V-cut jaws over the straight jaws for this work.



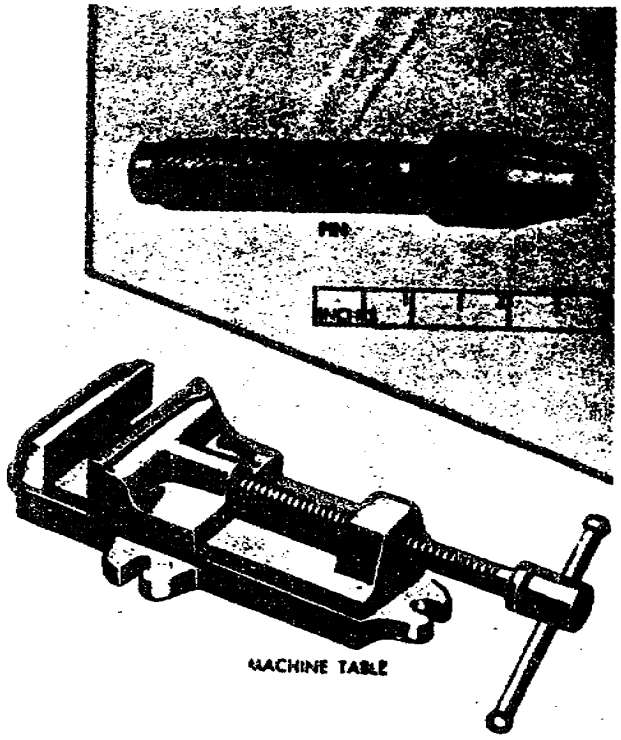


Figure 31. Blacksmith's and pipe vises. **Figure 32. Special purpose vises.**

(e) Finished work should be held between jaws of soft material or soft metal such as copper, brass, lead, or plastic. A piece of rawhide or soft leather laid over the vise jaws will prevent damage to highly polished surfaces.

(3) Care of vises. Keep vises clean at all times; they should be cleaned and wiped with light oil after using. Never strike a vise with a heavy object and never hold large work in a small vise, since this practice will cause the jaws to become sprung or otherwise damage the vise. Keep jaws in good condition and oil the screws and the slide frequently. Never oil the swivel base or swivel jaw joint-its holding power will be impaired. When the vise is not in use, bring the jaws lightly together or leave a very small gap and leave the handle in a vertical position.

EXERCISE

Note. - Answer each group of questions before continuing lesson.

1. The hammer most commonly used by mechanics is the

    a. cross peen.
    b. ball peen.
    c. straight peen.

2. What type of wrench is designed to use interchangeable handles?

    a. Crowfoot
    b. Combination
    c. Socket

3. The size of a screwdriver is determined by the

    a. length of the blade.
    b. overall length of the screwdriver.
    c. width of the tip should equal the length of the screw slot.

4. What should be remembered when using a screwdriver?

    a. Use the shortest screwdriver available
    b. Use soap on machine screws to drive screws easier
    c. Width of the tip should equal the length of the screw shaft

5. Which pliers are considered as special purpose pliers?

    a. Battery terminal
    b. Lineman's side-cutting
    c. Slip joint combination

6. Which type vise usually has the smallest holding capacity?

    a. Machinist's bench
    b. Clamp base bench
    c. Bench and pipe

5. EDGED HANDTOOLS.

a. General. Edged handtools are designed with sharp edges for working on metal, wood, plastic, leather, cloth, glass, and other materials. They are used for cutting, punching, scraping, chiseling, filing, etc. Most edged tools have hard cutting edges or points and require extreme caution when using.

b. Files. Files are used for cutting, smoothing off, or removing small amounts of metal. Files are made in various lengths, shapes, and cuts, and spacing of their teeth. Every file has five parts: point, edges, face of cutting teeth, heel or shoulder, and tang (fig 33).

(1) Types of files. File teeth characteristics.

(a) Single cut. Single cut files (fig 34) have a single set, diagonal row of teeth. The teeth are parallel to each other throughout the file.

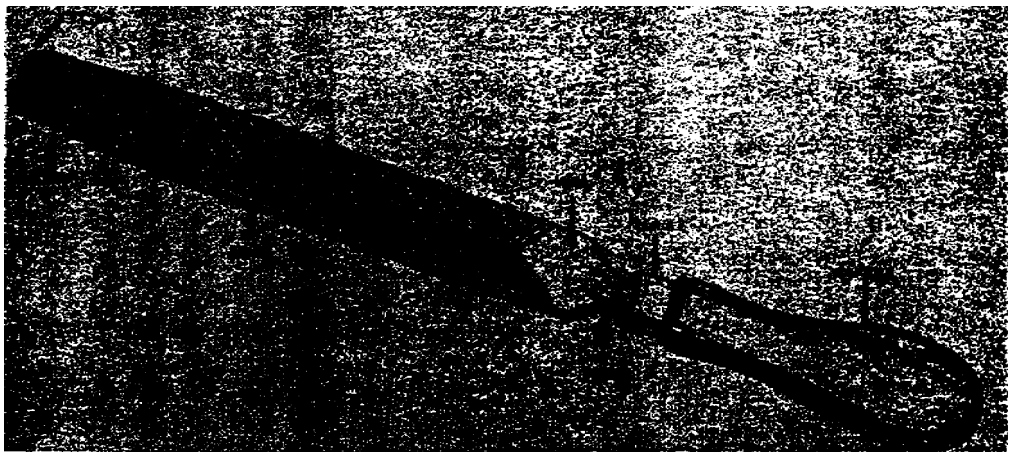


Figure 33. Parts of a file.

(b) Double cut. Double cut files (fig 34) have two sets of diagonal rows of teeth. The first set of teeth is called the overcut. On the top of the overcut set, a second set is made crossing the first. The second set is called the upcut and is not as coarse or as deep as the overcut.

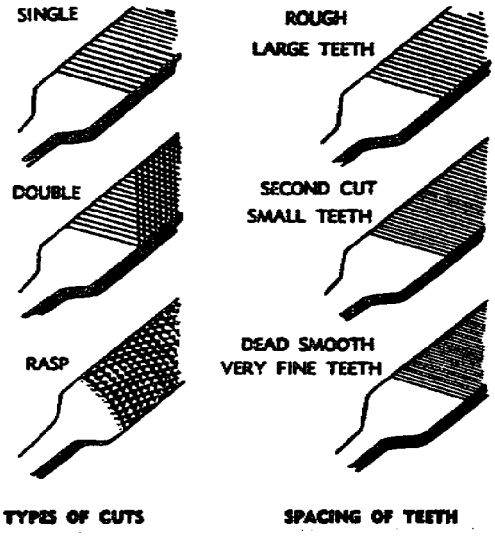


Figure 34. File teeth characteristics.

(c) Rasp cut. Rasp cut files (fig 34) are made by a single pointed tool or punch which forms each short tooth separately. Teeth are formed consecutively, side by side, to form a line or a row of teeth.

(2) File teeth spacing. The number of teeth per inch spacing (fig 34) varies slightly with the make of file. The spacing also changes with the file length, increasing proportionately as the length of the file is increased. A file may have a rough, coarse, bastard (medium coarse), second cut, smooth cut, and dead smooth grade teeth. For fast removal of metal or for rough work, the rough coarse and bastard files are used. For finishing, the second cut (small teeth), smooth cut (very small teeth), and the dead smooth (very fine teeth) are used.

(3) File shapes (fig 35).

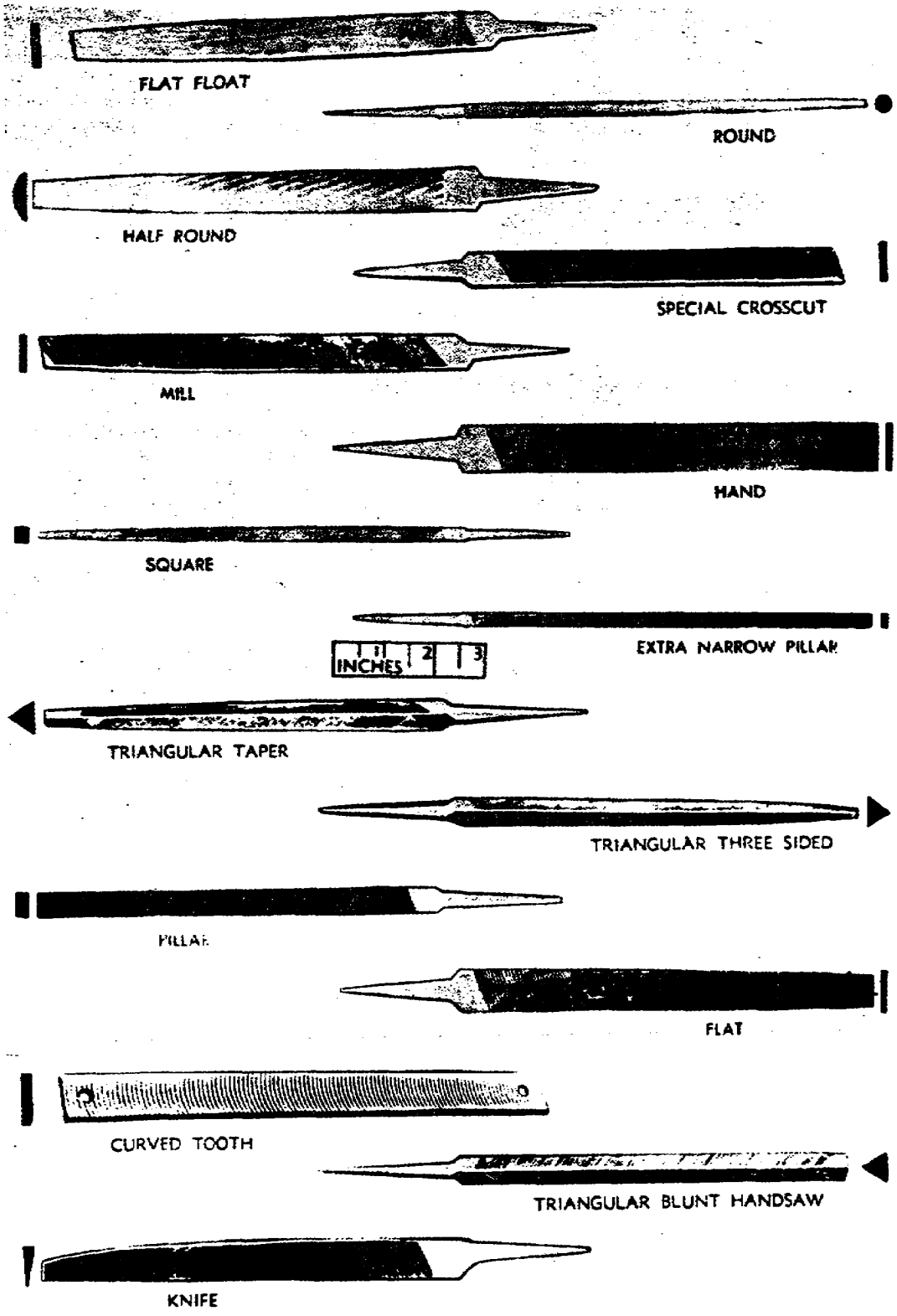


Figure 35. Types of files.

(a) Flat files. A flat file is rectangular in cross section and is slightly tapered toward the point in both width and thickness and has double-cut teeth. Both edges are cut.

(b) Hand files. A hand file is similar to a flat file, but is of uniform width and tapers in thickness only. It is double cut with one safe or uncut edge.

(c) Square files. A square file tapers slightly toward the point on all four sides and is double cut.

(d) Round files. A round file tapers slightly toward the point. The bastard cut files, 6 inches and longer, are double cut, The second cut round files, 12 inches and longer, are double cut. All others are single cut.

(e) Half-round files. A half-round file tapers toward the point in widths and thickness. The flat sides of all half-round files are double cut and are graded in coarseness like flat files. The round backs of all coarse and bastard half-round files are double cut. The backs of files longer than 6 inches are double cut, while the backs of 4-and 6-inch files are single cut.

(f) Mill files. A mill file is usually single cut and is tapered in width and thickness for about a third of its length.

(g) Pillar files. A regular or an extra narrow pillar file is similar to a hand file only it is narrower. Pillar files are double cut with one safe or uncut edge. Pillar files are of the same coarseness as square files of corresponding lengths.

(h) Triangular files. The taper file tapers toward the point, is usually single cut, and has edges that are set and cut for filing the gullet between saw teeth. The blunt handsaw file is of uniform width and thickness and its teeth are similar to those of the taper file. The three-sided file tapers toward the point, is double cut, and has fairly sharp corners.

(i) Knife files. A knife file is shaped like a knife blade and is double cut on both faces.

(j) Flat float files. Flat float files are slightly tapered in width and thickness and have a coarse cut.

(k) Curved tooth files. The curved tooth file has single cut, curved milled teeth, and is sometimes called a vixen or body file.

(1) Special crosscut saw files. The special crosscut saw file is single cut and of uniform width and thickness.

(m) Swiss pattern files. Swiss pattern files (fig 36) are small and delicate. The tang is shaped into a handle. They are most often used for fitting parts of delicate mechanisms, for filing work in instruments, and tool and die work. They are made in seven cuts--00, 0, 1, 2, 3, 4, and 6. They are usually supplied in sets of 8 or 12 assorted files in a box although individual files are issued. The handles are knurled for a better grip. The Swiss pattern files are designed in 12 different shapes.

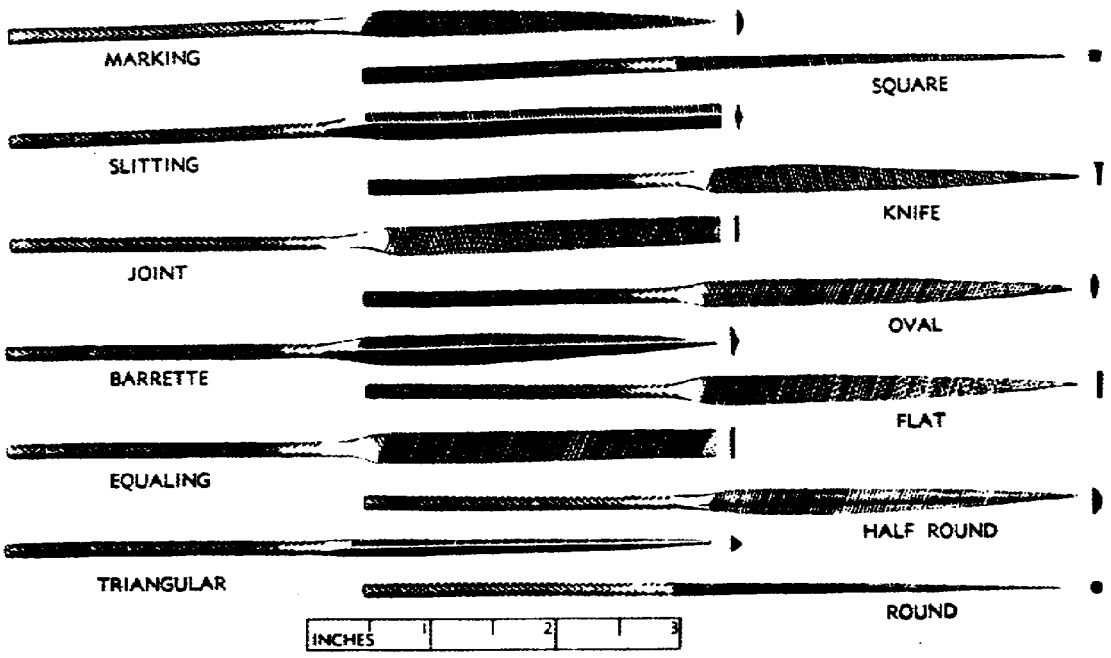


Figure 36. Swiss pattern files.

(4) Use of files. There are thousands of kinds, cuts, and sizes of files. This is due to the fact that there are thousands of different filing jobs, each of which can be done better by using the right file for the job. Therein lies the first rule on how to get the most out of files. The right file enables doing the job properly, whereas the wrong one does not and often, in fact, ruins the work. The right file saves time because it performs correctly, and usually faster, on the kind of metal or work for which it was designed. The right file permits a greater number of efficient filing strokes. Many factors enter into the selection of the right file for the job. In general, it may be said that different files are required to file a flat or convex surface; to file a curved or concave surface; to file an edge; to file a notch, a slot, or a square or round hole. But these factors can immediately become complicated by the kind of metal or other material to be filed; the kind, shape, and hardness of the object or part to be filed; the location, size, and character of the surface, edge, notch, slot, or hole to be filed; the amount of metal to be removed; and the degree of smoothness or accuracy required. All these conditions have a bearing on the kind, size, and cut of file which will best attain a particular objective.

(5) Selecting proper file.

(a) For heavy, rough cutting, a large coarse, double cut file is best.

(b) For finishing cuts, use a second cut or smooth cut, single cut file.

(c) When working on cast iron, start with a bastard cut file and finish with a second cut file.

(d) When filing soft metal, start with a second cut.

(e) When filing hard steel, start with a smooth cut file and finish with a dead smooth file.

(f) When filing brass or bronze, start with a bastard cut file and finish with a second or smooth cut file.

(g) When filing aluminum, lead, or babbitt metal, use a bastard cut curved tooth file.

(h) For small work use a short file; for medium sized work use an 8-inch file; for large work use a file that is most convenient.

(6) Method of filing.

(a) Clamp the work securely in a vise so that the area to be filed is horizontal and is parallel to, and projecting slightly above, the vise jaws.

(b) Hold the file handle in one hand, thumb on top, and hold the tip of the file with the fingers of the other hand.

(c) Apply pressure on the forward stroke only. Unless the file is lifted from the work on the return stroke, it will become dull much sooner than it should. When filing soft metals, pressure on the return stroke helps keep the cuts in the file clean of waste metal.

{d) Use a rocking motion when filing round surfaces.

(e) When using a new file, do not apply too much pressure since the teeth will break off - do not force the file. File slowly, lightly, and steadily. Too much speed and too much pressure cause the file to rock and will round off the corners of the work.

(f) Draw filing is used to produce a very smooth and true surface. To draw file, hold the file at right angles to the direction of the strokes, with your hands close together to prevent bending or breaking the file. Pressure should not be great and can remain the same on the back stroke, as well as on the draw stroke. The speed of filing is not important. For extra smooth surfaces, wrap a piece of emery cloth around the file and stroke in the same manner.

(7) Care and safety precautions.

(a) Breaking in. A new file should be broken in by using it first on brass or bronze. Never use it first to remove the fins or scales on cast iron. Do not use a new file on a narrow surface, such as sheet metal, because the narrow edge of the metal is likely to break off the sharp points on the file teeth.

(b) Cleaning. After using a new file, the teeth will clog up with metal filings. Using a clogged file will scratch the work - this condition is called pinning. One way to help prevent pinning is by rubbing chalk between the teeth before filing. However, the best method to keep the file clean is to use a file scorer and file cleaner brush. A scorer is a small pointed metal instrument, often furnished with the file cleaner brush, and is used for cleaning out individual teeth and grooves in the file clogged too tightly with metal to clean with the brush. When cleaning a file with a file scorer, use a pulling motion, holding the file scorer blade parallel to the rows of teeth. Finish cleaning by brushing the file parallel to the rows of teeth with the file cleaner brush.

(c) Safety precautions.

1. Do not throw files in a drawer or tool box where they can rub against each other or against other tools. Store them in separate holders, such as clips, straps, or in holes cut in a block of wood.

2. Use the files as instructed and clean them often.

3. Never use a file without a securely attached handle unless it is of the Swiss pattern type.

4. Do not use files for a purpose other than for which they were intended.

5. Do not use oil since this will cause the file to slide across the work preventing fast cutting.

6. Never strike the file against a vise or other object to remove filings. Use the file cleaner brush.

7. Never store files with lubricants or rust-preventive compounds on them. Wrap each file in a waterproofed barrier wrapping paper and place the files in racks or boxes so that the faces or edges of the files will not touch each other. Keep files dry.

c. Hacksaws. These are saws used for cutting metal, much the same as a carpenter's saw cuts wood. Common hand hacksaws have either adjustable frames or solid frames. Hacksaw blades of various types are inserted in these frames, for different kinds of work. Adjustable frames can be changed to hold blades from 8 to 16 inches long; solid frames, although more rigid, will take only the length blade for which they are made. This length is the distance between the two pins which hold the blade in place. All hacksaw frames hold the blades either parallel or at right angles to them and are provided with screws for pulling the blades tight.

(1) Hacksaw blades. Hacksaw blades are made of high-grade tool steel, hardened and tempered. There are two types: all-hard and flexible. AU-hard blades are hardened throughout, while only the teeth of the flexible blades are hardened. All blades are from 7/16 to 9/16 inch wide, have from 14 to 32 teeth per inch, and are from 8 to 18 inches long. Each blade has a hole at each end which hooks to pins in the frame.

(2) Set. The teeth of all hacksaw blades are set to provide clearance for the blade; the three different kinds of set are alternate set, raker set, and undulated set. Alternate set means that alternate teeth are bent slightly sidewise in opposite directions; on a raker set blade, every third tooth remains straight and the other two are set alternately; on an undulated set blade, short sections of teeth are bent in opposite directions. A blade should be set just enough to give a free, smooth, rapid cut in a slot just wider than the blade itself, removing no more stock than is necessary.

(3) Selecting hacksaw blades. Selecting the best hacksaw blade for a specific job is a question of using either an all-hard or flexible blade having a pitch (number of teeth per inch) best suited to the work in hand.

(a) An all-hard blade is best for sawing brass, tool steel, cast iron, rails, and other stock of heavy cross section.

(b) In general, a flexible blade is best for sawing hollow shapes and metals of light cross section, such as channel iron, tubing, tin, copper, aluminum, or babbitt.

(c) Use a blade with 14 teeth per inch on machine steel. This coarse pitch makes the saw free and fast cutting.

(d) Use a blade with 18 teeth per inch on solid stock, aluminum, babbitt, tool steel, high speed steel, cast iron, and so on. This pitch is recommended for general use.

(e) Use a blade with 24 teeth per inch on tubing, tin, brass, copper, channel iron, and sheet metal over 18 gage. If a coarser pitch is used, the thin stock will end to strip the teeth out of the blade and make it difficult to push the saw. Two or more teeth should be in contact with the work.

(f) Use a blade with 32 teeth per inch on thin-walled tubing and conduit and sheet metal thinner than 18 gage.

d. Shears and cutters.

(1) Hand shears.

(a) One of the handiest tools for cutting light sheet metal is the hand snip tin snips). The straight hand snips (fig 37) have blades that are.-straight and cutting edges that are sharpened to an 85° angle. Snips like this can be obtained in different sizes ranging from the small 6-inch snip to the large 14-inch. They are designed to cut sheet metal up to one-sixteenth inch in thickness. They will also work on a slightly heavier gages of soft metals such as aluminum alloys.

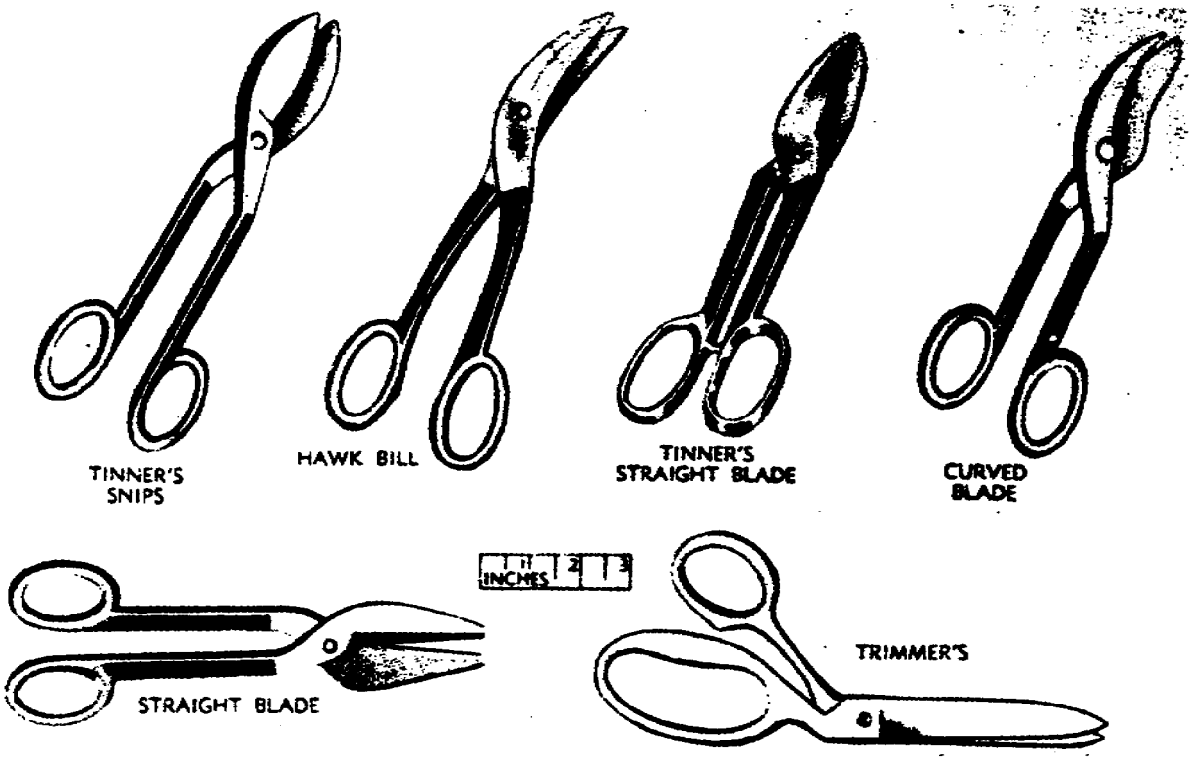


Figure 37. Hand shears.

(b) Snips will not remove any metal when a cut is made. There is a danger, though, of causing minute metal fractures along the edges of the metal during the shearing process. For this reason it is better not to cut exactly on the layout line in an attempt to avoid too much finish work.

(c) Cutting extremely heavy gage metal always presents an opportunity to spring the blades. Once the blades are sprung, hand snips are useless. Use the rear portion of the blades only when cutting heavy material. This not only avoids the possibility of springing the blades but also gives you greater cutting leverage.

(d) It is hard to cut circles or small arcs with straight snips. There are snips especially designed for circular cutting. They are called hawk-bill snips and aviation snips. Use these snips in the same manner as you would use straight snips and observe the same precautions. Like straight snips they come in many different sizes.

(e) Many snips have small serrations (notches) on the cutting edges of the blades. This tends to prevent them from slipping backwards when a cut is being made. Although this feature does make the actual cutting much easier, it mars the edges of the metal slightly. You can remove these small cutting marks if you allow proper clearance for dressing the metal to size. There are many other types of hand snips used for special jobs. The snips discussed here can be used for almost any common type of work.

(f) Learn to use snips properly. They should always be oiled and adjusted to permit ease of cutting and to produce a surface that is free from burs. If the blades bind, or if they are too far apart, the snips should be adjusted.

(g) Never use snips as screwdrivers, hammers, or pry bars. They break easily. Do not attempt to cut heavier materials than the snips are designed for. Never toss snips in a toolbox where the cutting edges can come into contact with other tools. This dulls the cutting edges and may even break the blades. When snips are not in use, hang them on hooks or lay them on an uncrowded shelf or bench. Never use tin snips to cut hardened steel wire or other similar objects. Such use will dent or nick the cutting edges of the blades.

(2) Bolt cutters. Bolt cutters (fig 38) are used to cut bolts, rod, wire rope, cable, screws, rivets, nuts, bars, strips, and wire. A bolt cutter is shaped like a giant shears with short blades and long handles. Different cutting edges are designed for specific applications.

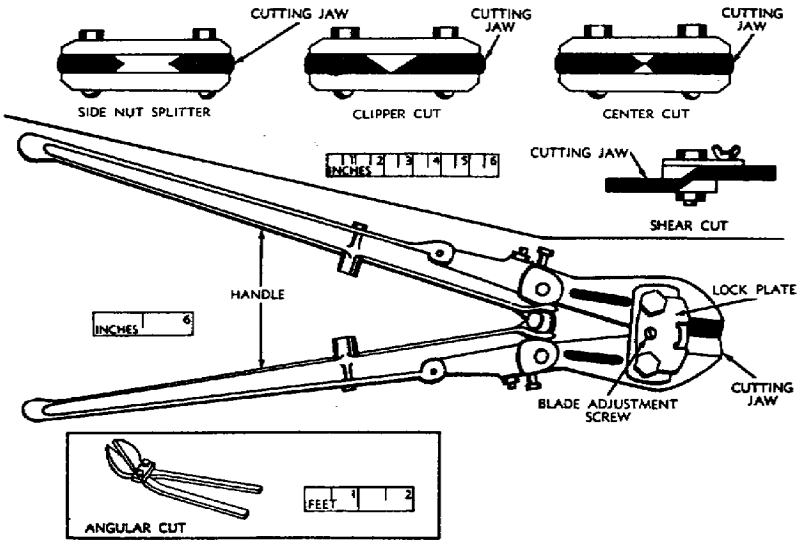


Figure 38. Types of bolt and nut cutters.

(3) Care of shears and cutters. Keep tools clean at all times. Lubricate pivot screw or bolt with a drop of light oil. Remove rust with a fine aluminum oxide abrasive cloth. Apply a thin film of oil on tools to prevent rust, and hang tools on hooks or place them on a shelf when not in use. Never throw tools in a box where the cutting edges may be damaged. Do not attempt to cut material harder than the tool was designed to handle. Never use shears or cutters as a hammer or a pry bar, since they are easily damaged. For long periods of storage, coat tools with a rust preventive compound and store them in a dry place where the cutting edges do not come in contact with other metal objects.

e. Chisels.

(1) Chisels are tools that can be used for chipping or cutting metal. They are made from a good grade tool steel with a hardened cutting edge and a beveled head. They will cut any metal that is softer than materials of which they are made. When it is skillfully used, the chisel can be made to do most any job that a milling machine can do, although it is perhaps less accurate and requires greater time and energy.

(2) Usually the bar stock from which a chisel is forged is octagonal (eight-sided). Cold chisels are classified according to the shape of their points, and the width of the cutting edge denotes their size. The most common shapes of chisels are flat (cold chisel), cape, roundnose, and diamond point (fig 39).

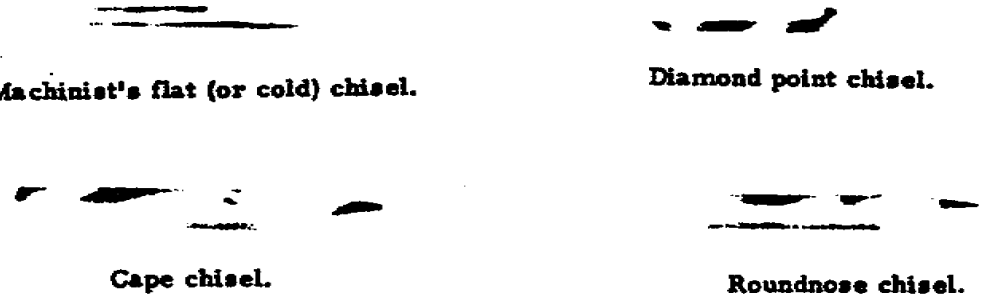


Figure 39. Chisels.

(3) The type chisel most commonly used is the flat cold chisel which serves to cut rivets, split nuts, chip castings, and cut thin metal sheets. Also used for special jobs is the cape chisel for cutting keyways, narrow grooves, and square corners; the roundnose chisel for semicircular grooves and for chipping inside corners with a fillet; and the diamond point for cutting V-grooves and sharp corners.

(4) As with other tools there is a correct technique for using a chisel. Select a chisel that is large enough for the job. Be sure to use a hammer that matches the chisel; that is, the larger the chisel the heavier the hammer. A heavy chisel will absorb the blows of a light hammer and will do virtually no cutting. As a general rule, hold the chisel in the left hand with the thumb and first finger about 1 inch from the top. It should be held steadily but not tight. The finger muscles should be relaxed, so if the hammer strikes the hand it will slide down the tool and lessen the effect of the blow. Keep the eyes on the cutting edge of the chisel, not on the head, and swing the hammer in the same plane as the body of the chisel. If you have a lot of chiseling to do, slide a piece of rubber hose over the chisel. This will lessen the shock to your hand.

(5) When using a chisel for chipping. always wear goggles to protect your eyes. If other men are working close by, see that they are protected from flying chips by erecting a screen or shield to contain the chips. Remember that the time to take these precautions is before you start the job.

f. Punches.

(1) A hand punch is a tool that is held in the hand and struck on one end with a hammer. There are many kinds of punches designed to do a variety of jobs and most are made of tool steel. The part held in the hand is usually octagonal shaped or it may be knurled. This prevents the tool from slipping around in the hand. The other end is shaped to do a particular job. Figure 40 shows some of the most common used metal punches.

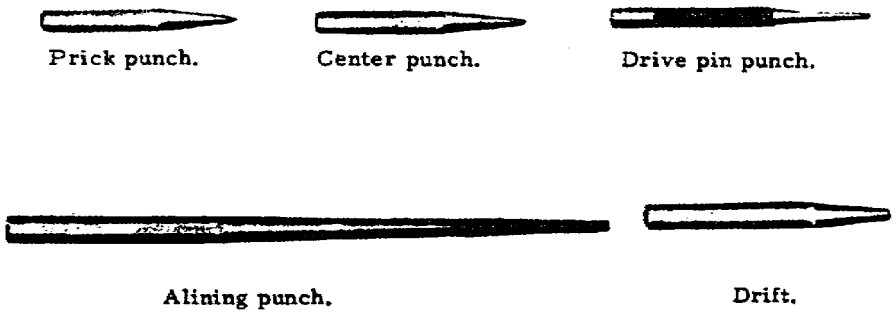


Figure 40. Commonly used metal punches.

(2) Drift punches, sometimes called "starting punches", have a long taper from the tip to the body. They are made that way to withstand the shock of heavy blows. They may be used for knocking out rivets after the heads have been chiseled off, or for freeing pins which are "frozen" in their holes. After a pin has been loosened or partially driven out, the drift punch may be too large to finish the job. The followup tool to use is the pin punch, for it is designed to follow through the hole without jamming. Always use the largest drift or pin punch that will fit the hole. These punches usually come in sets of three to five assorted sizes and will have flat points, never edged or rounded. To remove a bolt or pin that is extremely tight, start with a drift punch that has a point diameter slightly smaller than the diameter of the object you are removing. As soon as it loosens, finish driving it out with a pin punch. Never use a pin punch for starting a pin, because it has a slim shank and a hard blow may cause it to bend or break.

(3) Another punch you will use a lot is the center punch. As the name implies, it is used for marking the center of a hole to be drilled. If you try to drill a hole without first punching the center, the drill will "wander" or "walk away" from the desired center. Another use of the center punch is to make corresponding marks on two pieces of an assembly to permit reassembly in their original positions. The point of a center punch is accurately ground central with the shank, usually at a 60° angle, and is difficult to regrind by hand with any degree of accuracy. It is, therefore, advisable to take care of a center punch and not to use it on extremely hard materials.

(4) Other punches have been designed for special uses. One of these is the soft-faced drift. It is made of brass or fiber and is used for such jobs as removing shafts, bearings, and wrist pins from engines. It is generally heavy enough to resist damage to itself, but soft enough not to injure the finished surface on the part that is being driven.

(5) A prick punch is made of hardened tool steel ground to a slender, long tapered, cone-shaped point terminating in a sharp 30° conical tip. It is used to mark or identify scribed or layout lines on a piece of work, usually soft metal such as brass. These marks are made at short intervals so that the reference lines will be easily located.

EXERCISE

7. Which file should be used to file the gullet between saw teeth?

   a. Triangular
   b. Pillar
   c. Flat float

8. The hacksaw blade recommended for general use is the blade with

   a. 14 teeth per inch.
   b. 24 teeth per inch.
   c. 18 teeth per inch.

9. When cutting light sheet metal, which tool will not cause any metal to be removed?

   a. Hacksaw
   b. Snips
   c. Trimmers

10. Which chisel is used for cutting keyways?

   a. Diamond point
   b. Machinist flat
   c. Cape

11. Which punch is used to lay out lines on a piece of work?

   a. Prick
   b. Drift
   c. Center

SECTION III. PRECISION MEASURING TOOLS

6. MEASURING TOOLS.

a. General. Measuring tools are designed for measuring work accurately. They include level indicating devices, noncalibrated measuring tools (calipers, dividers) for transferring dimensions, calibrated measuring tools (rules, tapes, micrometers) designed to measure distances in accordance with one of several standards of measurements, gages which are machined to a predetermined shape and size for measurement by comparison, and combination tools such as combination square designed to perform two or more types of operations.

b. Rules. All rules (scales) are used to measure linear dimensions. They are read by a comparison of the etched lines on the scale with an edge or surface. Most scale dimensions are read with the naked eye, although a magnifying glass can be used to read graduations on a scale smaller than 1/64 of an inch.

(1) Types of rules.

(a) Steel rules. Steel rules (fig 41) are available from a fraction of an inch in length up to 4 feet or more, but in machine shops the 6-inch pocket rule is the one most commonly used. There are also several standard systems of graduations. In the English system, rules are graduated in 10ths, 20ths, 50ths, and 100ths; 12ths, 24ths, and 48ths; 14ths and 28ths; and 16ths, 32ds, and 64ths of an inch. In the Metric system, rules are graduated in millimeters and one-half millimeters. Some steel rules have four scales, two on each side (one graduated in 32ds and the other in 64ths), with the scales on the reverse side running in the opposite directions. There are rules made that have both an inch scale and millimeter scale, which makes this type rule adaptable to work involving both systems of measure. Another feature on some rules is a scale etched across the end of the rule which facilitates measurement in restricted places.

1. Flexible rule. A flexible rule (fig 41) is made of thin, tempered spring steel which permits it to be bent over a rounded surface.

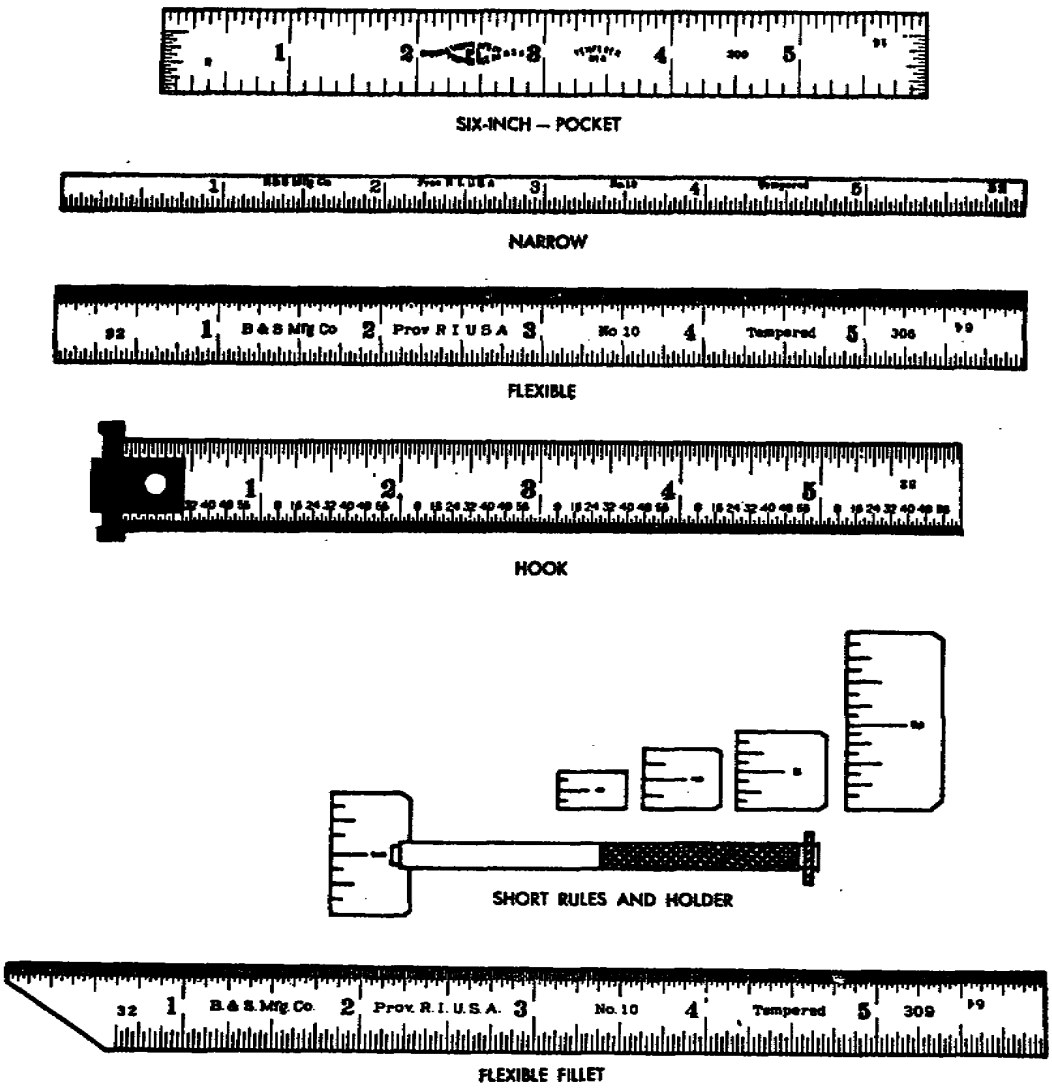


Figure 41. Types of steel rules.

2. Hook rule. A hook rule (fig 41) has a sliding hook which facilitates measuring from a shoulder, particularly if the end of the rule is hidden so that it cannot be lined up with the shoulder. The sliding hook is also convenient in setting calipers and dividers.

3. Short rules and holders. Short rules with a holder (fig 41) are available for measuring in a recess or in a restricted area.

4. Flexible fillet rule. A flexible fillet rule (fig 41) is used to span fillets and corner fills which are frequently in the way when measuring flanges, shoulders. and so forth.

(b) Folding rules. Folding rules (fig 42) are obtainable in wood or metal, having 4 to 12 folds, from 2 to 6 feet long total length. These rules cannot be relied on for extremely accurate measurements because a certain amount of play develops at the joints after they have been used for a time.

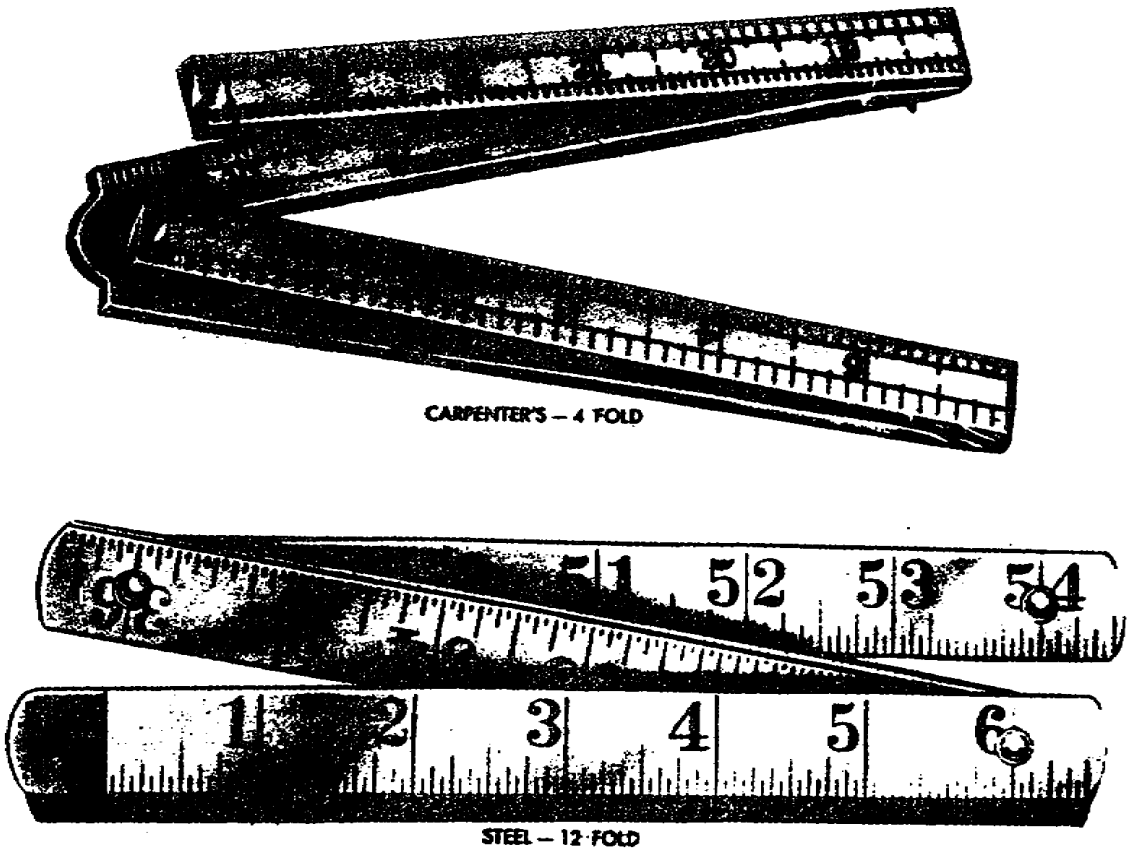


Figure 42. Types of folding rules

(2) Using the rule.

(a) Select proper scale. When using a rule to check a dimension, the proper graduated scale should be used to control the reading of the dimension (A, fig 43). If the work being measured lines up between two graduations on the scale as shown in B and C, figure 43, and it is not possible to read this dimension to a 1/16 on a 1/16-inch scale, a 1/32-inch scale should be used, and if it is still impossible to read a dimension to a 1/32, a 1/64-inch scale should be used.

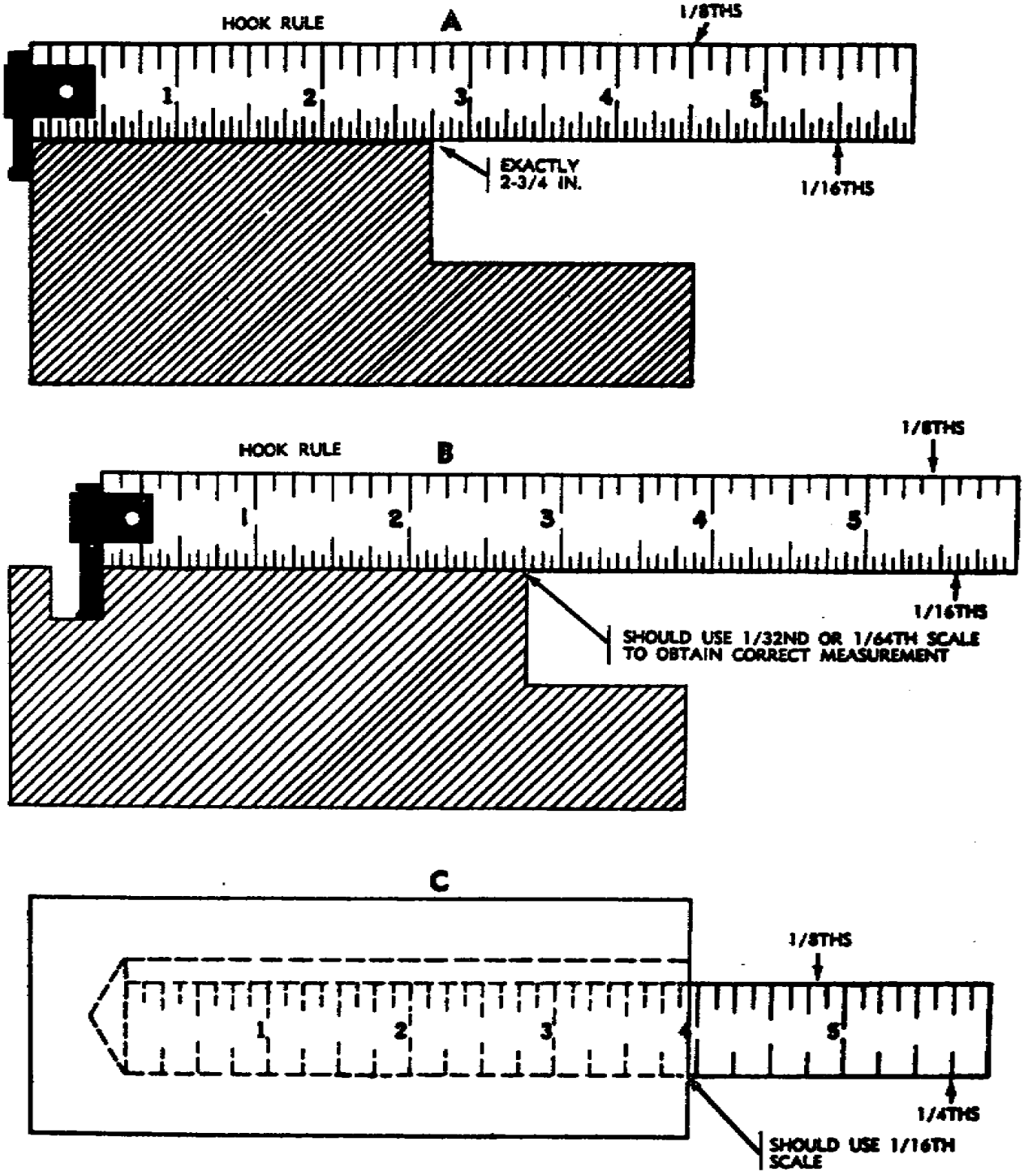


Figure 43. Determining proper graduated rule.

(b) Applications.

1. Six-inch rule. It is good practice to carefully line up the end of the rule with the surface from which the measurement is to be taken. Figure 44 shows the mechanic holding the part and the rule firmly against an angle block. This allows the user to devote his entire attention to reading the scale correctly. Figure 45 illustrates the use of a rule in checking the location of a gaging surface from a surface plate. The surface plate in this case serves as a common base and locates the rule in relation to the surface on the part measured.

Note. - Always measure stock at right angles.

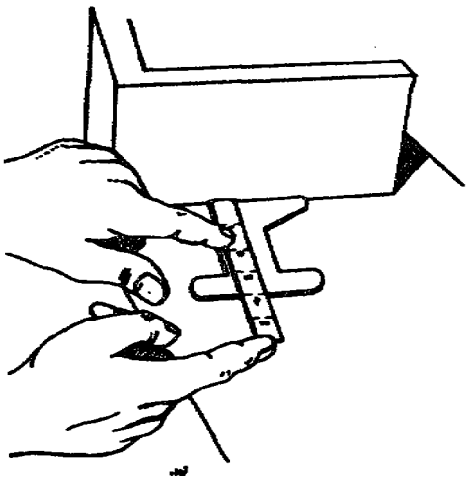


Figure 44. Using 6-inch rule.

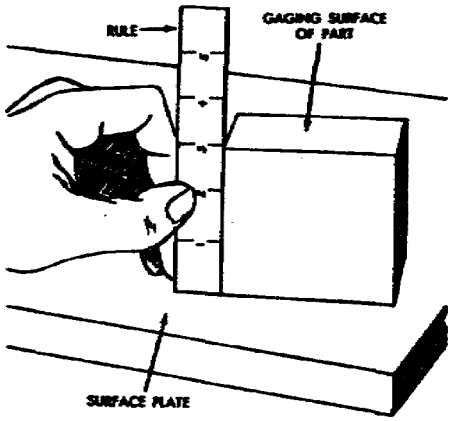


Figure 45. Using rule on surface plate.

2. Short rule and holder. Figure 46 shows how a short steel rule with holder may be usefully applied to a measurement in a recess inaccessible to the longer type rule.

3. Narrow rule. The narrow rule is used to advantage in measuring the depth of a narrow slot (fig 47).

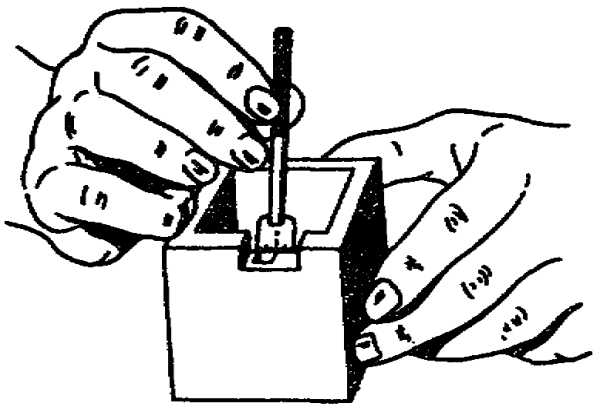


Figure 46. Using small rule and holder.

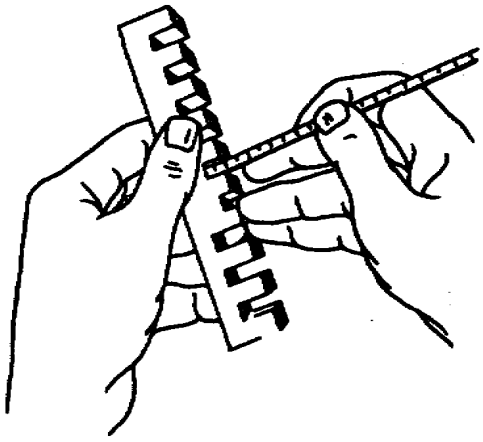


Figure 47. Using a narrow rule.

4. Key seat clamps and rule. Figure 48 illustrates the method of scribing a line on cylindrical stock, using key seat clamps and rule.

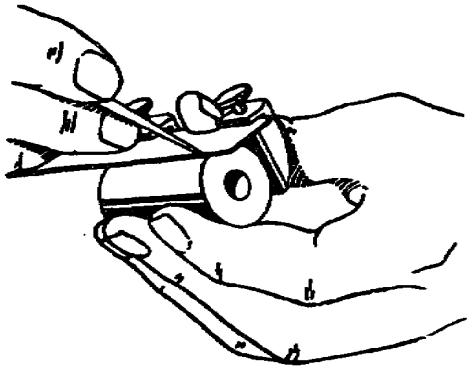


Figure 48. Using key seat clamps, rule, and scriber.

(3) Care of rules. Coat all steel rules with a rust-preventive compound or oil before storage. Make certain wood rules are stored in a dry place and are properly wrapped to preserve the wood. Clean rules before and after use, so that graduations are always legible. Periodically, check straightedges against a master surface plate for accuracy. The slightest nick will result in an incorrect reading. Do not use rules for purposes other than those intended.

c. Tapes. Tapes are used for measuring long distances and circumferences where rules cannot be applied.

(1) Types of tapes (fig 49).

Figure 49. Tapes.

(a) Steel tape. Steel tapes are made from 6 to 100 feet in length. In the shorter lengths, they are frequently made with a curved cross section so that they are flexible enough to roll up, but remain rigid when extended. Long, flat tapes require support over their full length when measuring or the natural sag will cause an error in reading.

(b) Tape rule. The tape rule is a ribbon of flexible steel that is wound into a flat metal case by pressing a button or pushing it in by hand. A hook is provided at one end to hook over the object being measured so that one man can handle it without assistance. On some models, the outside of the case can be used as one end of the tape when measuring inside dimensions.

(2) Care of tapes.

(a) Tapes should be handled carefully and kept lightly oiled to prevent rust. Never allow the edges of measuring devices to become nicked by striking them with hard objects. They should preferably be kept in a wooden box when not in use.

(b) To avoid kinking tapes, pull them straight out from their cases-do not bend them backward. With the windup type, always turn the crank clockwise-turning it backward will kink or break the tape. With the spring-wind type, guide the tape by hand. If it is allowed to snap back, it may be kinked, twisted, or otherwise damaged.

d. Calipers. These are used for measuring diameters and distances or for comparing dimensions or sizes with standards such as a graduated rule.

(1) Outside calipers. Outside calipers (fig 50) are used to measure distances over and around adjacent surfaces and to transfer the measurements to a rule. Several types are made in different sizes to accommodate a wide range in measurements. The size of the caliper is expressed in terms of the maximum dimension it is capable of measuring. A 3-inch caliper, for example, will measure a distance of 3 inches. Actually, the maximum capacity of a caliper will be greater, often as much as one-third. This means that a 3-inch caliper will actually measure up to 4 inches; however, it is not recommended that you use a 3-inch caliper to measure 4 inches, since you may spring the legs resulting in an inaccurate measurement.

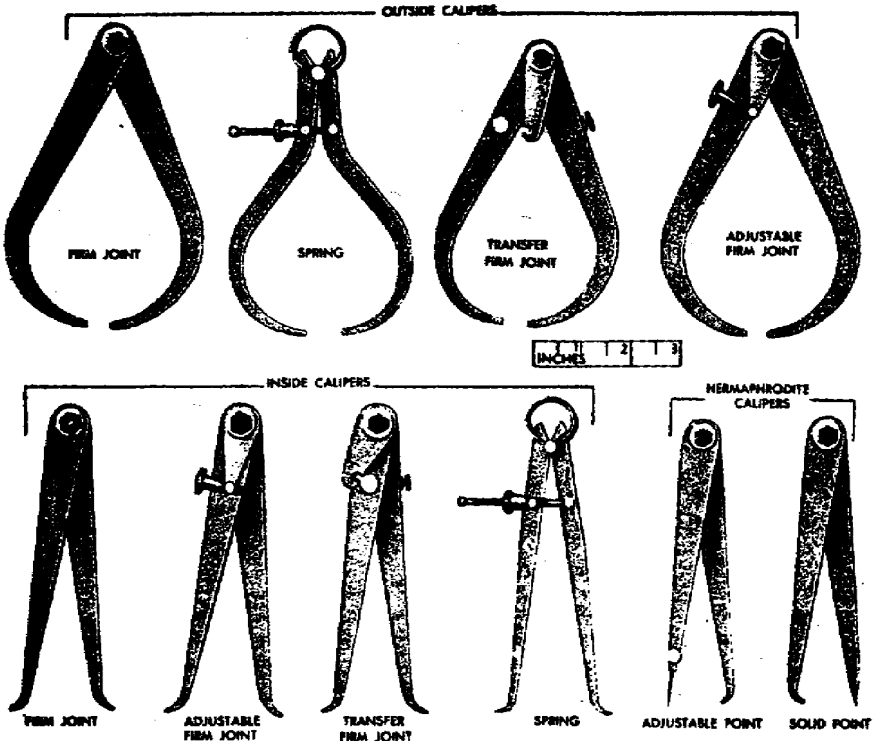


Figure 50. Calipers-noncalibrated.

(2) Inside calipers. Inside calipers (fig 50) have the same general function as outside calipers, except, that where the latter are used in measuring distances over outside surfaces, the inside caliper is used in measuring distances between inside surfaces. The points are rounded so that they are slightly ball-shaped. This ball shape establishes the point of contact, and in inside callipering where the surfaces are likely to have an inside curvature an error may occur if the radius of the hole being callipered is less than the radius of the points. Some inside calibers are equipped with an adjusting screw on one leg which provides a fine adjustment of the caliper legs.

(a) Spring caliper.

1. The spring caliper is available in sizes from 2 to 8 inches. The friction of the adjusting nut and screw works against the tension of the spring which holds the legs in any set position. This type of inside caliper is known as the toolmaker's spring caliper.

2. Thread spring calipers are used to measure diameter and distances in tapped holes. The ends of the legs of thread calipers are shaped to a fine point so that exact contact may be made between threads.

(b) Firm joint caliper. The firm joint type is available in a number of sizes from 3 to 24 inches. This type of caliper is equipped with a nut and stud that provide sufficient friction to hold the legs in any set position. Some of this type caliper are equipped with an adjusting screw for fine adjustments.

(c) Transfer firm joint caliper. Inside transfer firm joint calipers are shaped for inside measurements and are used for measuring recesses where the setting cannot be transferred to a scale directly because the legs must be collapsed to remove them from the work.

(3) Use of calipers.

(a) Outside calipers. A caliper is usually used in either of two ways. Either the caliper is set to the dimension of the work and the dimension transferred to a scale, or the caliper is set on a scale and the work machined until it checks with the dimension set up on the caliper. To adjust an outside caliper to a scale dimension, one leg of the caliper should be held firmly against one end of the scale and the other leg adjusted to the desired dimension (A, fig 51). To adjust the outside caliper to the work, open the legs wider than the work and then bring them down to the work. A sense of feel must be acquired to use calipers properly. This comes through practice and care in using the tool to eliminate the possibility of error. Always position the caliper properly on the axis of the work (B, fig 51).

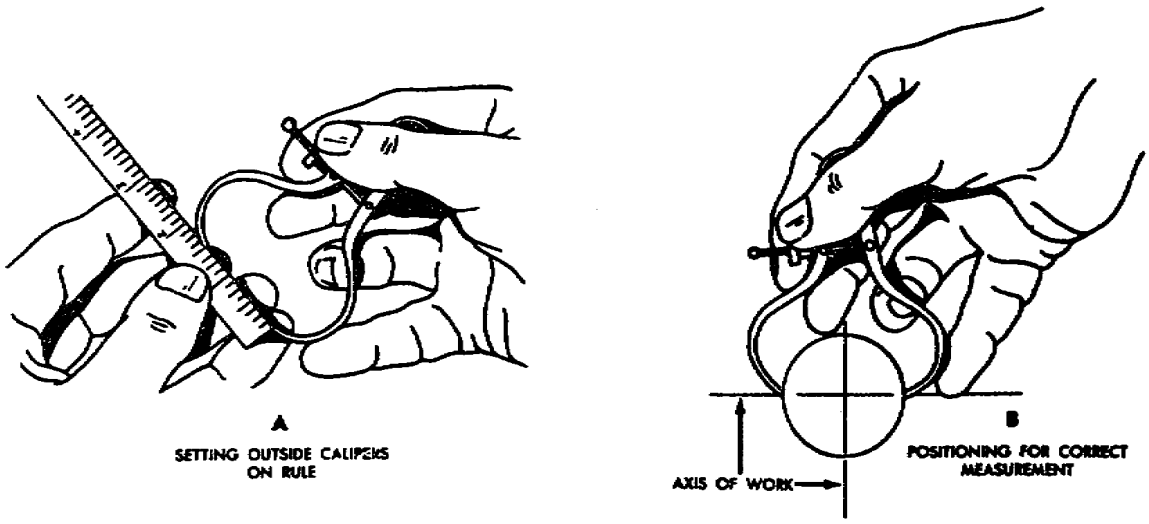


Figure 51. Using outside calipers.

(b) Inside calipers. The inside caliper is set to a dimension by placing the end of a scale and one point of the caliper against a solid surface and adjusting the other leg to the proper graduation (A, fig 52). The spring caliper is shown being used to check the inside diameter of a bored hole (B, fig 52). Figure 53 illustrates the correct and incorrect positioning of the calipers with relation to the axis of the work. The transfer feature of the caliper is illustrated in figure 54. Note that the diameter being used is recessed and that the setting cannot be transferred to a scale directly because the legs must be collapsed to get them out of the work. The setting must be reproduced after the calipers are removed. Figure 55 shows how a micrometer can be used to transfer a dimension from an inside spring caliper.

Figure 53. Positioning of inside calipers.

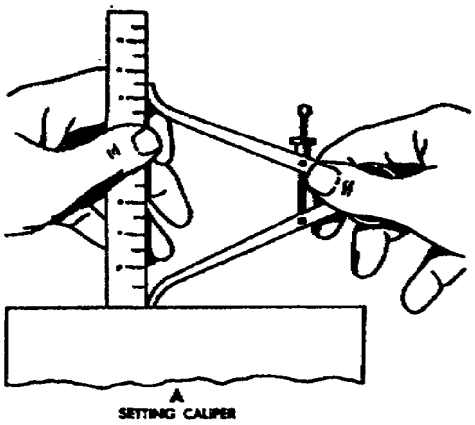


Figure 52. Setting and using inside caliper.

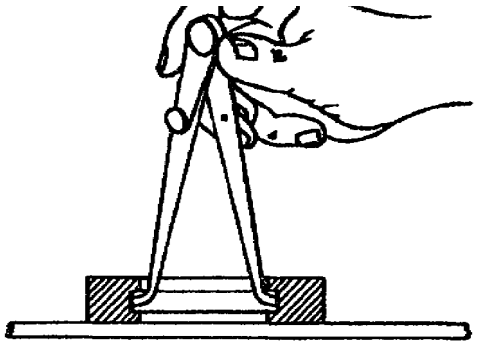
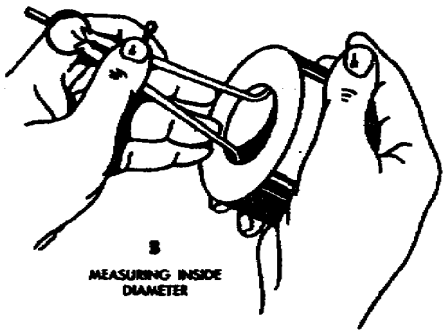


Figure 54. Using a transfer caliper to measure a recessed diameter.



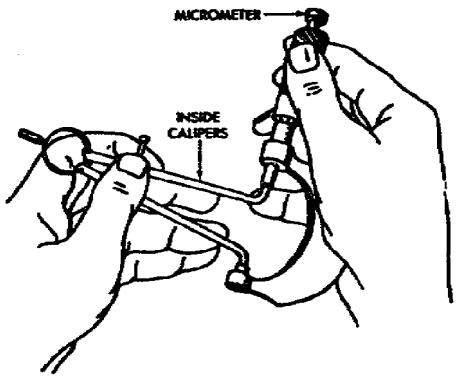


Figure 55. Transferring dimension to micrometer.

(4) Care of calipers. Never use a caliper for a purpose other than that for which it was intended. Never pile these tools in a drawer. Never force calipers beyond their capacity or setting. Never use these tools incorrectly-changing settings by hammering instead of loosening a clamping screw or nut, bearing down too hard when scribing with a divider, or wearing measuring surfaces unnecessarily by using a heavy measuring pressure. Apply a protective film of oil to tools when not in use.

e. Micrometers. These tools are used for measurements requiring precise accuracy. They are more reliable and more accurate than the calipers discussed in the preceding section.

(1) Types of micrometers. Micrometers are made in various shapes and sizes, depending upon the purpose for which they are to be used. They all have a precision screw adjustment offering great measuring accuracy.

(a) Micrometer caliper.

1. The micrometer caliper (fig 56) is the most common type. It has a range of 0 to 1 inch and is graduated to read in thousands of an inch or in units of the Metric system, from 0 to 25 millimeters by hundredths of a millimeter.

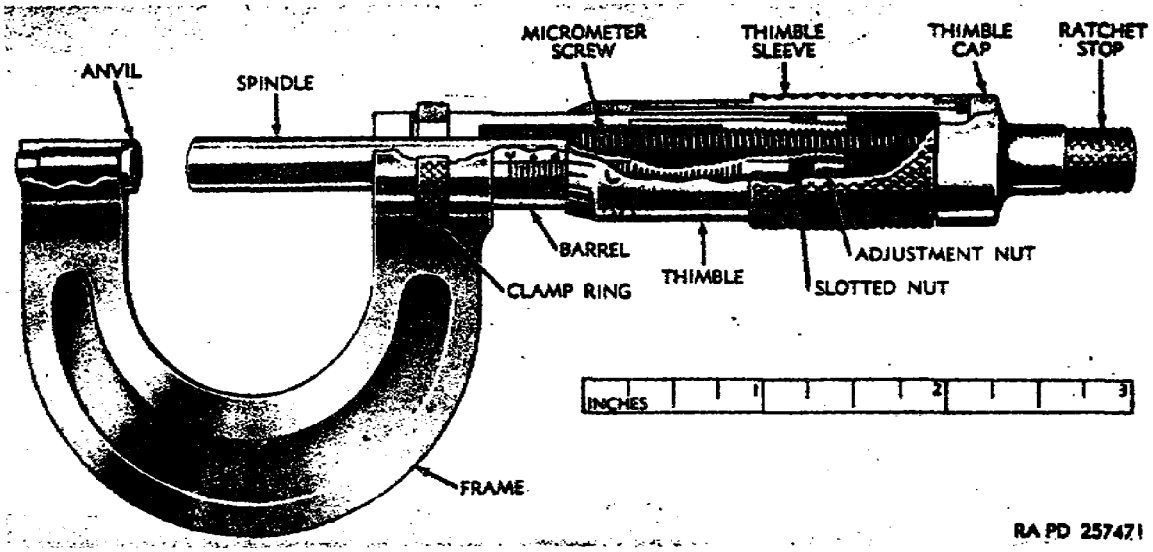


Figure 56. Micrometer, caliper, cutaway view.

2. The frame can be smaller to the extent that the range of the caliper is only 0 to 1/2 inch or 0 to 13 millimeters, or it can be larger so that the range is 23 to 24 inches. The head has a constant range of 0 to 1 inch. The shape of the frame may be varied to adapt it to the physical requirements of some types of work. For example:

a. The frame back of the anvil may be cut away to allow the anvil to be placed in a narrow slot.

b. The frame may have a deep throat to permit it to reach into center sections of a sheet (sheet metal or paper gage).

c. The frame may be in the form of a base so that the gage can be used as a bench micrometer.

d. The frame may have a wooden handle and may be of extra-heavy construction for use in a steel mill for gaging hot sheet metal.

3. The spindle and anvil may vary in design to accommodate special physical requirements. For example:

a. The spindle and anvil may be chamfered so that the gage can slide on and off the work easily, as when gaging hot metal.

b. The ball-shaped anvil is convenient in measuring the thickness of a pipe section of small diameter.

c. The V-shaped anvil is necessary on the screw thread micrometer caliper to mesh properly with the screw thread. The spindle of the screw thread micrometer is cone-shaped. This micrometer measures the pitch diameter.

d. The interchangeable anvils of various lengths make it possible to reduce the range of the caliper. A micrometer having a range from 5 to 6 inches can be changed to one having a 4- to 5-, or 3- to 4-inch range by inserting a special anvil of the proper length.

(b) Inside micrometers. Inside micrometers are used to measure inside dimensions. The minimum dimension that can be checked is determined by the length of the unit with its shortest anvil in place and the screw set up to zero. It consists of an ordinary micrometer head, except that the outer end of the sleeve carries a contact point attached to a measuring rod. The average inside micrometer set has a range that extends from 2 to 10 inches. The various steps in covering this range are obtained by means of extension rods. The micrometer set may also contain a collar for splitting the inch step between two rods. The collar, which is 1/2 inch long, extends the rod another half inch so that the range of each step can be made to overlap the next. The range of the micrometer screw itself is very short when compared to its measuring range. The smallest models have a 1/4-inch screw, the average have a 1/2-inch screw, and the largest inside micrometers have only a 1-inch screw.

(2) Mechanics of micrometers.

(a) Design. The micrometer (fig 56) makes use of the relation of the circular movement of a screw to its axial movement. The amount of axial movement of a screw per revolution depends on the thread, and is known as the lead. If a circular nut on a screw has its circumference divided into 25 equal spaces, and if the nut advances axially 1/40 inch for each revolution, then if it is turned one division, or 1/25 of a revolution, it will move axially 1/25 x 1/40, or 1/1000 of an inch. In the micrometer the nut is stationary and the screw moves forward axially a distance proportional to the amount it is turned. The screw on a micrometer has 40 threads to the inch, and the thimble has its circumference divided into 25 parts, so 1 division on the thimble represents an advancement of 1/1000 of an inch axially.

(b) Construction.

1. The steel frame is U-shaped, one end of which holds the stationary anvil. The stationary anvil is a hardened button either pressed or screwed into the frame.

2. The steel spindle is actually the unthreaded part of the screw. It the spindle that advances or retracts to open or close the open side of the U-frame. The spindle bearing is a plain bearing and a part of the frame.

3. The hollow barrel extends from this bearing, and on the side of the barrel is the micrometer scale, which is graduated in tenths of an inch, which are in turn divided into subdivisions of 0.025 inch. The end of the barrel supports the nut which engages the screw. This nut is slotted and its outer surface has a taper thread and a nut which make it possible to adjust the diameter of the slotted nut within limits to compensate for wear.

4. The thimble is attached to the screw and is a sleeve that fits over the barrel. The front edge of the thimble carries a scale broken down into 25 parts. This scale indicates parts of a revolution, where the scale on the barrel indicates the number of revolutions. The thimble is connected to the screw through a sleeve that permits it to be slipped in relation to the screw for the purpose of adjustment. The inner sleeve is sweated to the screw. The outer sleeve is clamped to the inner one by the thimble cap. Loosening the cap makes it possible to slip one in relation to the other.

5. On top of the thimble cap there may be a ratchet. This device consists of an overriding clutch held together by a spring in such a way that when the spindle is brought up against the work, the clutch will slip when the correct measuring pressure is reached. The purpose of the ratchet is to eliminate any difference in personal touch and so reduce the possibility of error due to a difference in measuring pressure. Not all micrometers have ratchets.

6. The clamp ring or locknut is located in the center of the spindle bearing on those micrometers equipped with it. This clamping makes it possible to lock the spindle in any position to preserve a setting.

(3) Use of micrometers.

(a) Reading standard micrometer. Reading a micrometer is only a matter of reading the micrometer scale or counting the revolutions of the thimble and adding to this any fraction of a revolution. The micrometer screw has 40 threads per inch. This means that one complete and exact revolution of the micrometer screw moves the spindle away from or toward the anvil exactly 0.025 inch. The lines on the barrel (fig 57) conform to the pitch of the micrometer screw, each line indicating 0.025 inch, and each fourth line being numbered 1, 2, 3, and so forth. The beveled edge of the thimble is graduated into 25 parts, each line indicating 0.001 inch, 1/25 of the 0.025 inch covered by one complete and exact revolution of the thimble. Every fifth line on the thimble is numbered to read a measurement in thousandths of an inch. Read the measurement shown in figure 57 as indicated in 1. through 4. below.

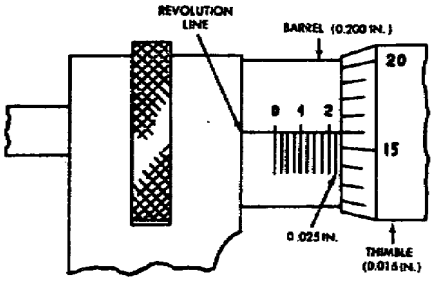


Figure 57. Reading standard micrometer scale.

1. Record highest figure visible on barrel..... 2 = 0.200 in

2. Number of lines visible between the No 2 and thimble edge..... 1 = 0.025 in

3. The line on the thimble that coincides with or has passed the revolution or long line in the barrel..... 16 = 0.016 in

4. Measurement reading.....TOTAL = 0.241 inch

(b) Reading metric micrometer. The same principle is applied in reading the metric graduated micrometer, but the following changes in graduations should be noted to avoid confusion:

1. The pitch of the micrometer screw is 0.5mm. One revolution of the spindle advances or withdraws the screw a distance equal to 0.5mm.

2. The barrel is graduated in millimeters, from 0 to 25; it takes two revolutions of the spindle to move 1mm.

3. The thimble is graduated in 50 divisions with every fifth line being numbered.

4. Rotating the thimble from one graduation to the next moves the spindle 1/50 of 0.5mm, or 1/100mm. Two graduations equal 2/100mm, and so forth.

(c) Adjusting micrometer caliper to work.

1. A, figure 58, shows the proper way to hold a micrometer caliper in checking a small part. Hold the part in one hand. Hold the micrometer in the other hand so that the thimble rests between the thumb and the forefinger. The third finger is then in a position to hold the frame against the palm of the hand. The frame is supported in this manner and makes it easy to guide the work over the anvil. The thumb and forefinger are in position to turn the thimble either directly or through the ratchet and bring the spindle over against the work.

2. On larger work, it is necessary to have the work stationary and positioned to permit access to the micrometer. The proper method of holding a micrometer when checking a part too large to be held in one hand is shown in B, figure 58. The frame is held by one hand to position it and to locate it square to the measure; surface. The other hand operates the thimble either directly or through the ratchet. A large flat part should be checked in several places to determine the amount of variation.

3. To gage a shaft as shown in C, figure 58, the frame is held by one hand while the thimble is operated by the other. In gaging a cylindrical part with a micrometer it is necessary to "feel" the setting to be sure that the spindle is on the diameter, and also to check the diameter in several places to determine the amount of out-of-roundness.

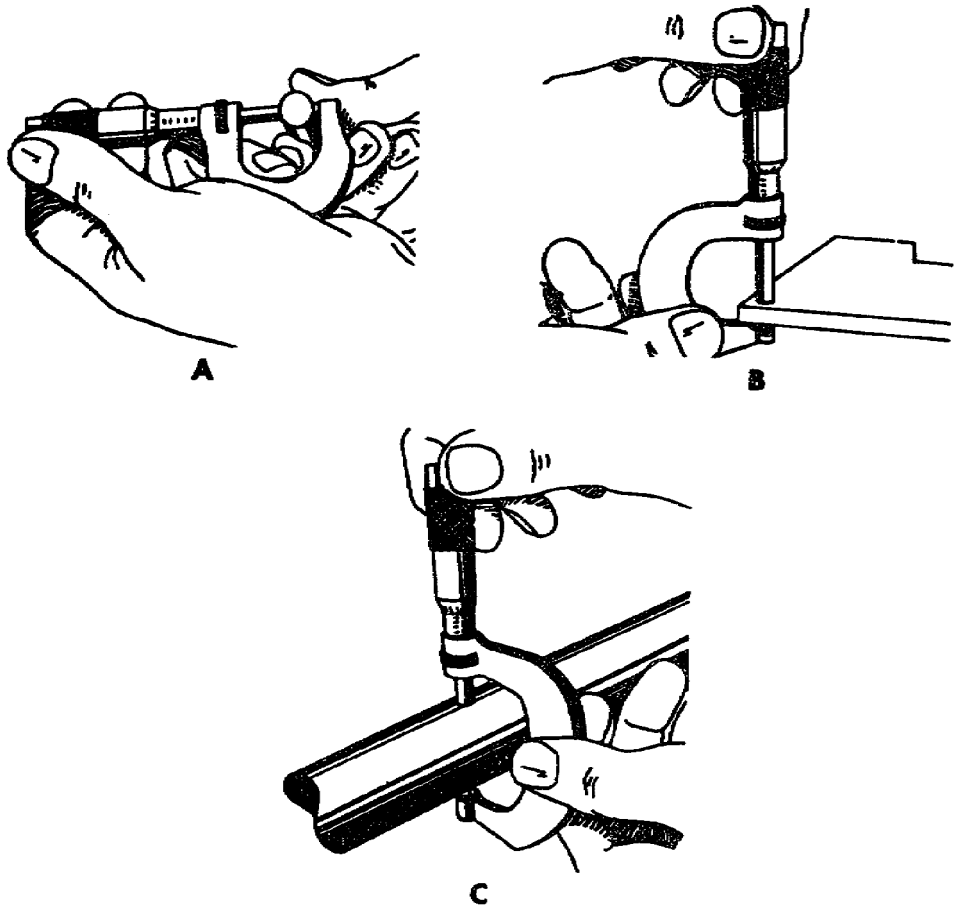


Figure 58. Using outside micrometer.

4. For measuring very large diameters, micrometer calipers are made in various sizes up to 168 inches. Figure 59 shows a pulley being checked with a micrometer whose range has been reduced by a special anvil which has been screwed into the frame. A set of different length anvils permits the use of this micrometer over a wide range of sizes; yet the spindle only moves 1 inch. This micrometer has been lightened in weight by the I-section construction and by boring holes in the frame.

(d) Using inside micrometer. The normal procedure in using an inside micrometer is to set it across a diameter or between the inside surfaces, remove it, and then read the dimension. For this reason, the thimble on an inside micrometer is much stiffer than on a micrometer caliper-it holds the dimension well. It is good practice to verify the reading of an inside micrometer by measuring it with a micrometer caliper.

1. Figure 60 shows an inside micrometer with extension rod being used to check the diameter of a bored hole. Note the arrows which indicate the direction the operator is feeling for the largest dimension horizontally and the smallest dimension vertically. Inside micrometers have spherical contact points which require more practice to "feel" the full diametral measurement. One contact point is generally held in a fixed position and the other rocked in different directions to be sure the tool is spanning the true diameter of a hole or the correct width of a slot.

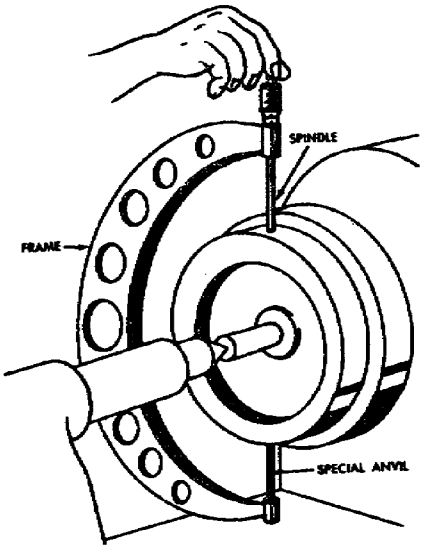


Figure 59. Checking diameter of pulley.

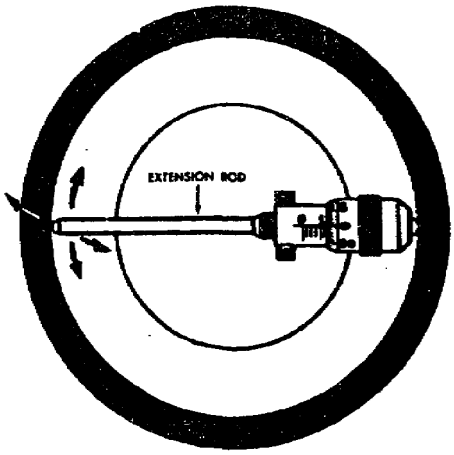


Figure 60. Using inside micrometer with extension rod.

2. For probing a deep hole or in a restricted place, a handle attachment may be used. The handle clamps on to the body of the micrometer.

(e) Transferring measurements from inside caliper or inside micrometer to micrometer caliper.

1. After setting the inside caliper or inside micrometer to the work, hold the micrometer caliper in one hand and the inside tool in the other hand.

2. Turn the thimble of the micrometer caliper with the thumb and forefinger until you feel the inside tool legs lightly contact the anvil and spindle of the micrometer caliper.

3. Hold the tips of the inside tool legs parallel to the axis of the micrometer caliper spindle.

4. The micrometer caliper will be accurately set when the inside tool will just pass between the anvil and spindle by its own weight.

(4) Care of micrometers. To maintain a micrometer in good condition and to preserve the accuracy of its measurements, observe the following rules of good practice and adjusting procedures.

(a) Never store a micrometer with its anvil and spindle closed. Flat surfaces wrung together for any length of time tend to corrode. Leave a small gap between the anvil and spindle when storing.

(b) Oil the micrometer in only one place-the micrometer screw, and only with a very light oil. If storing for long periods of time, cover the micrometer with a light film of oil and wrap it in oiled paper.

(c) Never roll the thimble along the hand or arm. Likewise, holding the thimble and twirling the frame to open or close the micrometer will cause excessive wear on the screw.

(d) Before using a micrometer, wipe it off and pull a piece of paper between the anvil and end of the spindle.

(e) The micrometer should operate freely with no play in its travel. If a micrometer has play, or if it binds, it should be returned to the manufacturer for reconditioning. This condition is caused by abuse or uneven wear.

(f) Check the micrometer screw periodically with a precision gage block in at least four places other than zero to verify its accuracy. Simply measure a selected group of blocks ranging from 0 to 1 inch.

(g) Clean micrometer mechanism whenever it becomes gummy, contains abrasive grit, or whenever it is to be adjusted. Use an approved cleaning agent.

(h) When the faces of the spindle and anvil become worn and they are no longer flat and parallel to each other, the error should not exceed 0.0002 inch on a micrometer which is graduated to control measurements to a limit of 0.001 inch and should not exceed 0.00005 inch on a micrometer which is graduated to control measurements to a limit of 0.0001 inch. Measuring a ball at several points over the surface of the anvils will show up any error in parallelism. Parallelism can be tested by means of two balls mounted in an aluminum holder. If the anvils are in error more than the allowable maximum, the micrometer should be returned to the manufacturer for repair.

(i) In adjusting a micrometer to read correctly, the thimble is not set to 0 when the anvil is in contact with the spindle, but is set at some dimension to distribute the error. For example, if a micrometer screw had an accumulating error of 0.0003 inch in the length of its travel, and it were set correctly at 0, it would be 0.0003 at 1 inch. However, if the micrometer were set correctly in the center of its travel, it would be 0.00015 under at 0 and 0.00015 over at 1 inch, which is a much better condition. Because a micrometer does not return exactly to 0 when the anvil and spindle contact, it does not mean that it is not adjusted properly. Turn the friction sleeve with a small spanner wrench to compensate for minor wear on the anvil and spindle or on the screw.

f. Thickness (feeler) gages.

(1) General. Thickness (feeler) gages are fixed in leaf form to permit the checking and measuring of small openings such as contact points, narrow slots and so forth. They are widely used to check the flatness of parts in straightening and grinding operations and in squaring objects with a try square. Thickness gages are made in many shapes and sizes; usually 2 to 26 blades are grouped into one tool and graduated in thousandths of an inch (fig 61). Most thickness gage blades are straight, but some are bent at the end at 45° and 90° angles. Some thickness gages are grouped so that there are several short and several long blades together. Thickness gages are also available in single blades and in strip form for specific measurements. For convenience, groups of thickness blades are equipped with a locking screw in the case that locks the blade to be used in the extended position.

(2) Care of gages. Always coat metal parts of all gages with a light film of oil when not in use to prevent rust. Store gages in separate containers. Do not pile gages on each other. Always return blades of leaf-type gages to the case after use. Keep graduations and markings on all gages clean and legible. Do not drop any gage--minute scratches or nicks will result in inaccurate measurements.

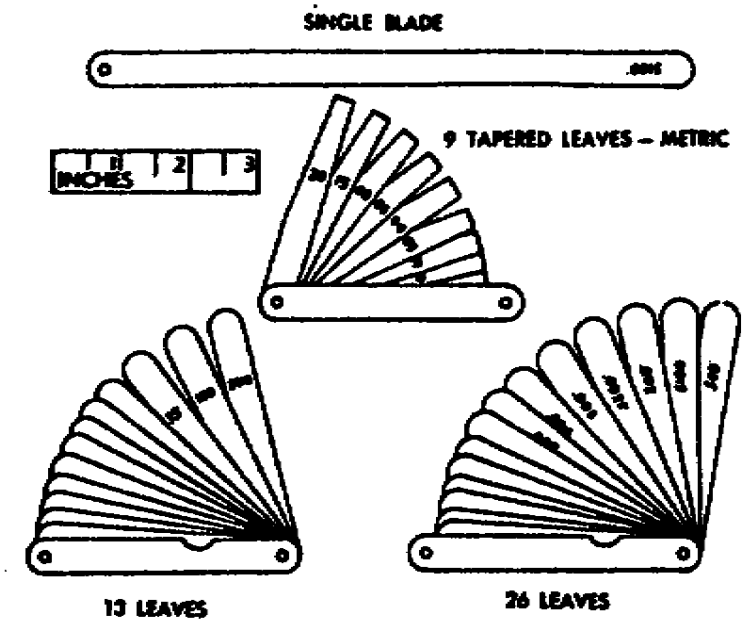


Figure 61. Thickness (feeler) gages.

EXERCISE

12. Which ruler is used conveniently in setting calipers?

    a. Flexible fillet
    b. Hook
    c. Six-inch pocket

13. Which caliper is used to measure an inside recessed diameter?

    a. Spring
    b. Hermaphrodite
    c. Transfer firm joint

14. What is the FIRST procedure when reading a standard micrometer?

    a. Read the number of lines visible on the barrel shown after the number
    b. Read the highest number on the barrel
    c. Read the number shown on the thimble

15. Which statement is TRUE concerning the metric micrometer?

    a. Barrel is graduated in millimeters from 0 to 25
    b. Thimble is graduated in 25 divisions with every fifth line being numbered
    c. It takes three revolutions of the spindle to move 1 millimeter

7. SUMMARY. In this lesson you have learned the use of many handtools and precision measuring tools. It would be impossible to cover all tools that you will come in contact with; however, the tools you will use the most in performing your mission have been discussed. Your awareness of their capability and constantly increasing your skill in their use will enable you to perform your duties more efficiently.

LESSON ASSIGNMENT

Ordnance Subcourse No 017.....	Supporting Services
Lesson 2.....	Pipefitting Procedures
Lesson Objective.....	After studying this lesson you will be able to: 1. Describe measuring, cutting, and threading of pipes, tubing, and fittings. 2. Explain and describe the tools used in preparing, forming, and connecting pipes and lines. 3. Explain pertinent safety procedures.
Text.....	Attached Memorandum
Materials Required.....	Response list and answer sheet
Suggestions.....	Study illustrations as the text is used.

ATTACHED MEMORANDUM

1. INTRODUCTION. Pipes and tubings can be prepared into many varied shapes and forms. The ability of the mechanic to prepare a pipe layout that will not leak and is safe to use will prevent many valuable pieces of equipment from being inoperable.

2. STEEL PIPE AND FITTINGS.

a. General. Pipe is used to distribute hot and cold water, for steam and hot water systems, gas and air piping systems, and vent installations. Most pipe in use today is steel pipe. It is furnished plain (black) or galvanized (coated with zinc), normally in 21-foot lengths, threaded or unthreaded, and in sizes (nominal inside diameter) of 1/8 inch and larger. In most sizes it is available in three weights or strengths: standard, extra strong, and double extra strong. Iron pipe may rust making it undesirable for most military use.

b. Fittings. Fittings used on either wrought iron or steel pipe are generally made of malleable (capable of being shaped by beating) or cast iron. Prolonged annealing (heating and fast cooling) of cast iron tempers and toughens it to produce malleable iron. This iron can be bent or pounded to some extent without breaking. Iron pipe fittings are of two general types: ordinary or pressure fitting and drainage or recessed fitting (1, fig 1). Drainage fittings (2 and 3, fig 1) differ from ordinary fittings (1, fig 1) in several ways: the insides are smooth and shaped for easy flow, shoulders are recessed so that when pipes are screwed in they fill the recess and form an unbroken internal contour and they are designed so that horizontal lines entering them will have a slope of 1/4 inch per foot. In an ideal drainage fitting the pipe fills the recess completely (2, fig 1), and there is no pocket where foreign matter may be caught and block the flow. This condition is rarely achieved and the made-up joint resembles 3, figure 1. Only drainage fittings should be used on soil and waste lines. Either ordinary or drainage fittings may be used for gas, air, vent, water, or steam systems.

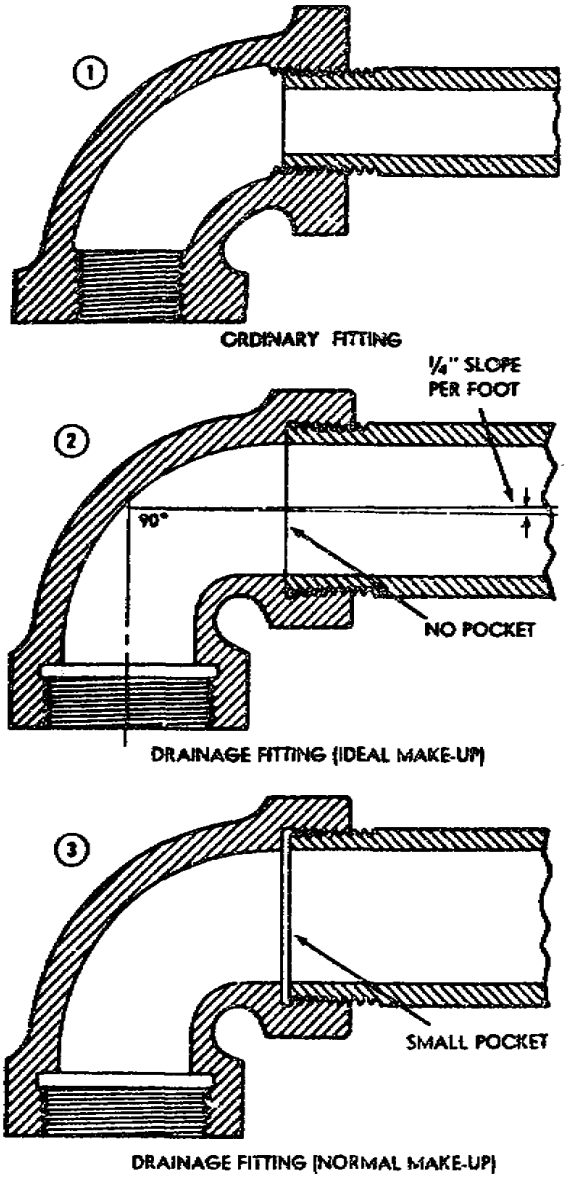


Figure 1. Difference between ordinary and drainage fittings.

c. T's (tees). When the three outlets of a T are the same size, the fitting is specified by that size; for example, a 1-inch T (1, fig 2). When the outlets are not the same size, the fitting is called a reducing T (2, fig 2) and is specified by giving the straight through (run) dimensions followed by the bide opening (branch) dimensions. Thus, a T with run outlets of 2 inches and a branch outlet of 1 inch is known as a 2 by 1 T; one with run outlets of 2 inches and 1 inch, respectively, and a branch outlet of 3/4 inch, as a 2 x 1 x 3/4 T. T's are also made with a run or branch outlet with male threads and with two branch outlets at right angles to each other (four-way T).

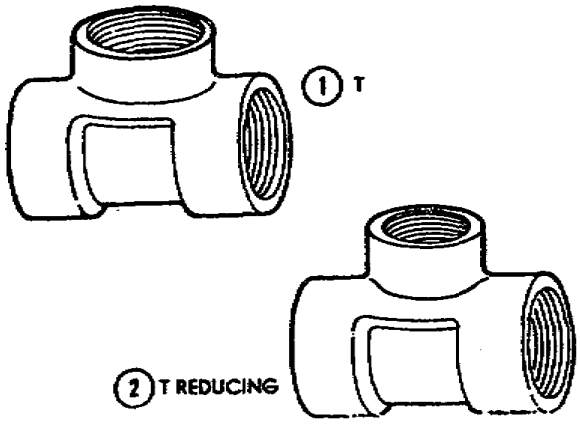


Figure 2. Iron pipe T's.

d. Elbows (L's or ells). Ells are used to change the direction of a pipeline. They, like T's, are made in a large variety of sizes and patterns. The most common types are the 90° ell (1, fig 3); 45° ell (2, fig 3); street ell (3, fig 3), which has a male thread on one end and is also made in angles other than the one illustrated; and the reducing ell (4, fig 3), which has outlets of different sizes.

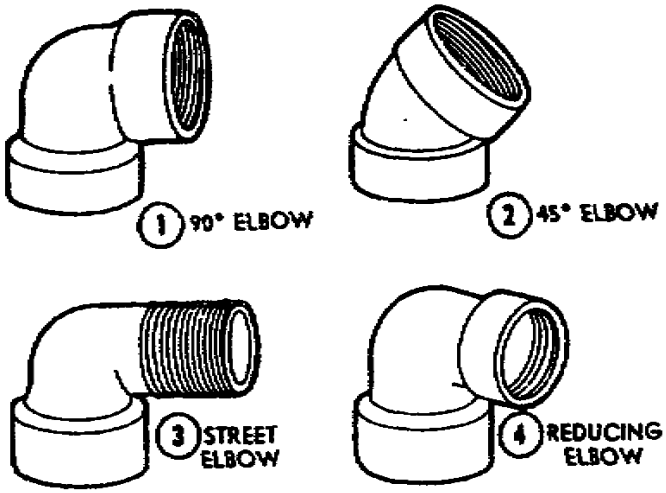


Figure 3. Iron pipe elbows.

e. Unions. The ground joint and flange unions are the two most common types of iron pipe unions. Both are used to join two pipes. The ordinary ground joint union (1, fig 4) has a shoulder piece with female threads, thread piece with female and male threads, ring or collar with an inside flange which matches the shoulder of the shoulder piece, and a female thread matching the male thread of the thread piece. The shoulder and thread pieces have a ground spherical joint. The pipes are screwed to the thread and shoulder pieces. Both pieces are drawn together by the collar, making a gastight and watertight joint. Another type of ground union joint (2, fig 4) is made in two parts, each of which is screwed to the pipes to be joined and then drawn together by nuts and bolts. The flange union (3, fig 4) has two parts, each with a female thread, which are screwed to the pipes to be joined. Nuts and bolts pull the flanges together. A gasket between the flange a makes a gastight and watertight joint. Plain faced flanges are shown; they may have male and female faces or tongue and groove faces.

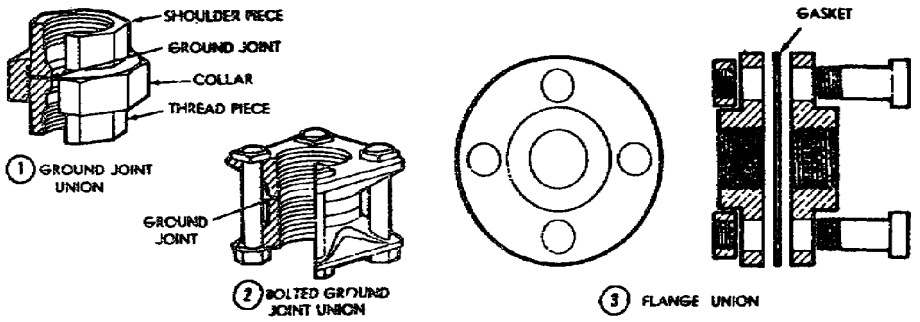


Figure 4. Iron pipe unions.

f. Couplings. The ordinary coupling (1, fig 5) is a short fitting with a female thread used to join two lengths of the same pipe size when making a straight run. It is not used to join two lengths of pipe already installed and relatively fixed; a union must be used in such cases. The reducing coupling (2, fig 5) is used to join two pipes of different sizes. The eccentric reducing coupling (3, fig 5) has female threads of different sizes and different centers. It is fitted so that the bottom of the two pipes joined will form a straight line to promote drainage. An example is in a steam line where it is undesirable to have a pocket where water could collect. Another type of coupling is the extension piece (4, fig 5), which has both male and female threads. There are many special couplings such as the Dresser coupling.

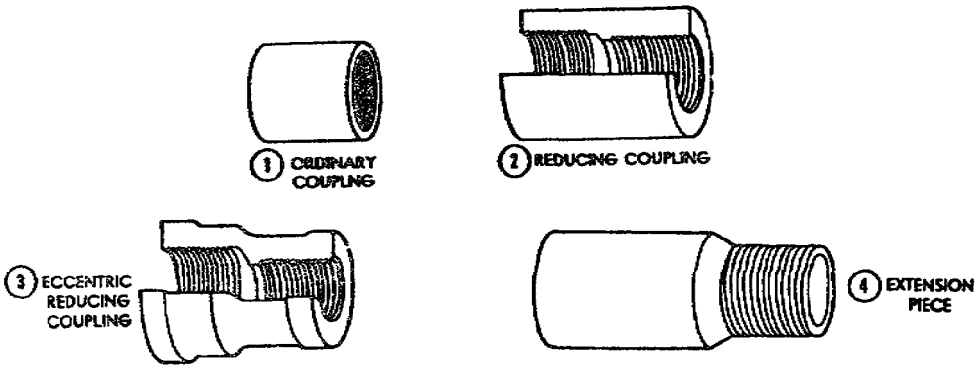


Figure 5, Iron pipe couplings.

g. Nipples. A nipple is a piece of pipe, 12 inches or less in length, threaded on both ends, and used to make an extension from a fitting or to join two fittings. A close nipple (1, fig 6), threaded its entire length, joins two fittings which must be very close to each other. A nipple threaded nearly its entire length with only a short unthreaded section in the center is called a short or shoulder nipple (2, fig 6). When the unthreaded portion is longer, the nipple is called a long nipple and sometimes an extra long nipple (3 and 4, fig 6). Long and extra long nipples are specified by length such as 4 inches, 6 inches, etc.

h. Crosses. An iron pipe cross (5, fig 6) is an ordinary T with an additional back outlet opposite the branch outlet. The axes of the four outlets are in the same plane and perpendicular to each other. Crosses are made in many sizes.

i. Plugs. Iron pipe plugs have male threads used to close openings in other fittings and have various types of heads. The square head (6, fig 6) is the most widely used; the slotted head (7, fig 6) is seldom used except in close spaces where a wrench cannot be used; and the hexagon socket head (8, fig 6) is used where a bulge would cause difficulty, as in a boiler or hot water storage tank fitted with an insulating jacket.

j. Caps. A pipe cap (9, fig 6) is a fitting with a female thread used like a plug except that the cap fits on the male end of a pipe or nipple.

k. Bushings. A bushing has male thread on the outside and female thread on the inside. It is generally used to connect the male end of a pipe to a larger fitting. The ordinary bushing (10, fig 6) has a hexagon nut at the female end for screwing the bushing into the fitting. The faced bushing, without a hexagon nut, is used for very close work.

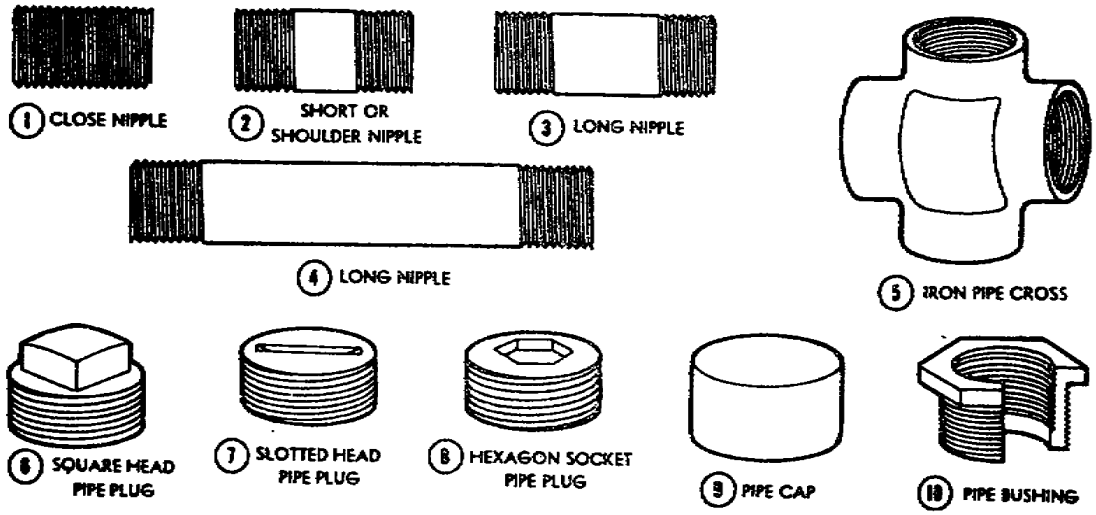


Figure 6. Miscellaneous iron pipe fittings.

3. COPPER TUBING AND FITTINGS.

a. Tubing.

(1) Uses. Copper tubing is used in hot and cold water distribution systems, in hot water heating systems, and in soil, waste, and vent lines. Copper is light, easily installed, and resists corrosion. Rigid copper tubing is hard tempered and comes in 20-foot lengths. It does not bend so changes in direction must be made with fittings. Flexible copper tubing is soft tempered, easily bent for changes in direction, and comes in coils of 40 to 100 feet, depending on size, Larger coils are available in the smaller sizes.

(2) Types and sizes.

(a) Type K has a heavy wall and is used for underground and other heavy duty purposes. It is available in hard and soft temper and in sizes from 1/4 inch to 6 inches.

(b) Type L has a medium wall and is used for general indoor plumbing where conditions do not require heavier tubing. It, too, is available in hard and soft temper and in the same sizes as type K.

(c) Type M has a thin wall and is used mainly in hot water heating systems. It is available only in hard temper in the same sizes as types K and L.

(d) Type DWV (drain, waste, and vent) is used only in aboveground soil, waste, and vent lines. It is furnished in hard temper only and in sizes from 1-1/4 inches to 8 inches. It comes in 12-foot lengths as-well as the standard 20-foot length.

b. Fittings.

{1) Solder-type fittings. These are the more widely used of the two types of fittings. They can be used with either rigid or flexible copper tubing and are made in the usual iron pipe patterns; i.e., T's, elbows, couplings, etc. Figure 7 shows solder-type fittings. In addition to those shown, solder-type fittings include reducing T's, reducing ells, T's with male or female iron pipe adapter outlets, iron pipe adapter ells, and others. Fittings for use with DWV copper pipe are similar to cast iron soil pipe fittings and include Y-branches, sanitary T's, combination Y and 1/8 bends, an adapter for joining to a cast iron soil pipe hub, and others.

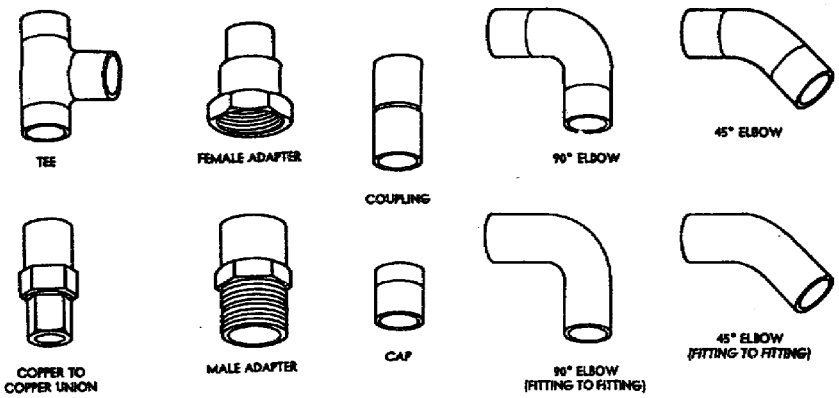


Figure 7. Solder-type fittings.

(2) Compression-type fittings. These fittings (fig 8), also known as flared fittings, are used only with flexible copper tubing. Their principal use is in air piping and in fuel oil lines because they resist vibration better than solder-type fittings. For general plumbing, they are not recommended for connections to be sealed in walls.

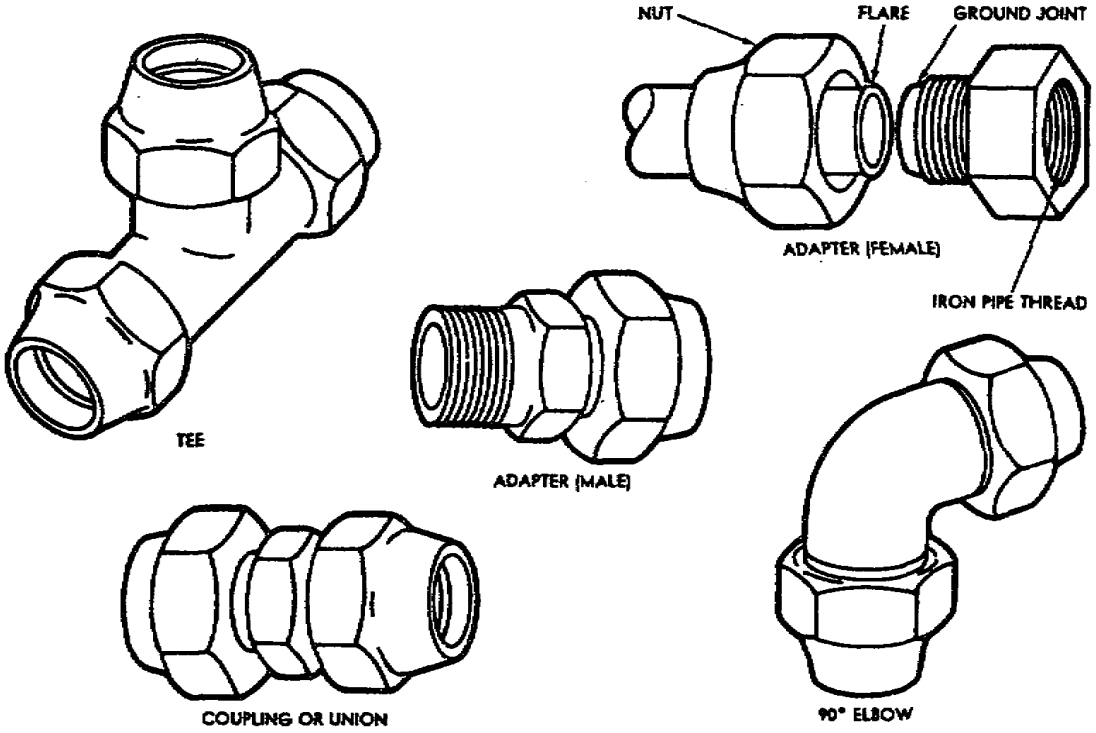


Figure 8. Compression-type fittings.

4. VALVES.

a. Definition. A valve is a device used to stop, start, or regulate the flow of a liquid or gas into, through, or from pipes. It usually is made of brass. The body of the valve has an opening and a way of closing the opening with a valve disk or plug which can be tightly pressed against a seating surface around or within the opening.

b. Types. Only a few of the many types are discussed here.

(1) Gate valve. The gate valve (1, fig 9) has a wedge-shaped movable gate which closely fits the movable seat when the valve is closed. When the valve is open, the gate clears the opening formed by the seat and allows a straight line passage for the flow. To limit wear on the gate and seat, gate valves should be used on lines which remain either completely open or shut most of the time. The valve shown is a rising stem, single disk, gate valve. Other common types are the double disk and the nonrising stem.

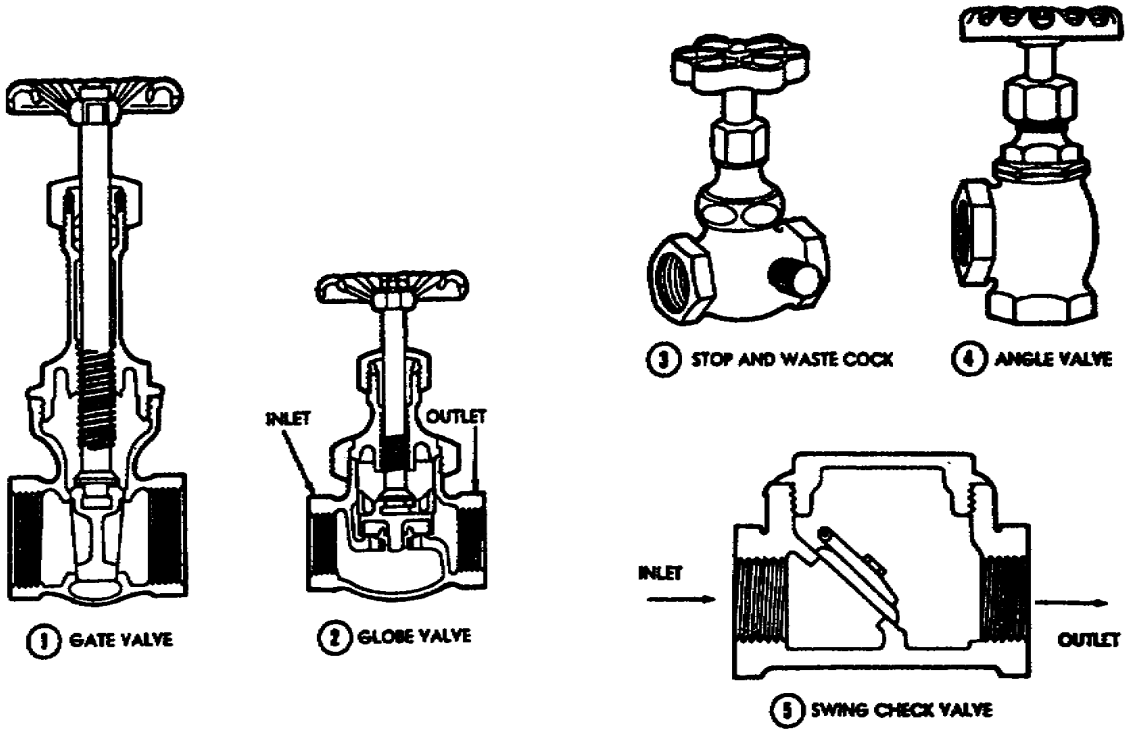


Figure 9, Types of valves.

(2) Globe valve. Outwardly, a globe valve (2, fig 9) looks like a gate valve but inside it is made quite differently. Partitions block the flow through the valve; and the seat, which is at right angles to the direction of flow, changes the direction of flow. The horizontal seat is a ground joint against which a replaceable fiber or metal disk or washer at the end of the stem makes a tight fit. Globe valves are used where adjustment of rate of flow is needed. Globe valves with fiber disks are suitable for all kinds of service except on steam lines, where a metal disk is preferred. A globe valve should be set in the line so that the inlet side will carry the pressure when the valve is closed.

(3) Stop and waste valve. This valve (3, fig 9) is similar to the globe valve except that it has a small drain opening on the outlet side of the valve body which can drain the line when the valve is closed. This valve is used in lines which may freeze if they are not drained in winter.

(4) Angle valve. This is a globe valve with inlet and outlet at 900 to each other (4, fig 9). It controls the flow and changes the direction of a line.

(5) Check valve. A check valve (5, fig 9) checks or prevents reversal of flow in the line. The one shown is a swing check. Other types are the disk check, ball check, and adjustable check.

(6) Other types. Other types of valves include pressure reducing valves and pressure or temperature relief valves.

5. MEASURING PIPE AND TUBING.

a. Pipe. There are several ways to measure threaded pipe; therefore, it is important to know which method is being used in any given measurement and to allow for fitting dimensions (end-to-end or end-to-center) and for length of thread engagement (fig 10 and 11).

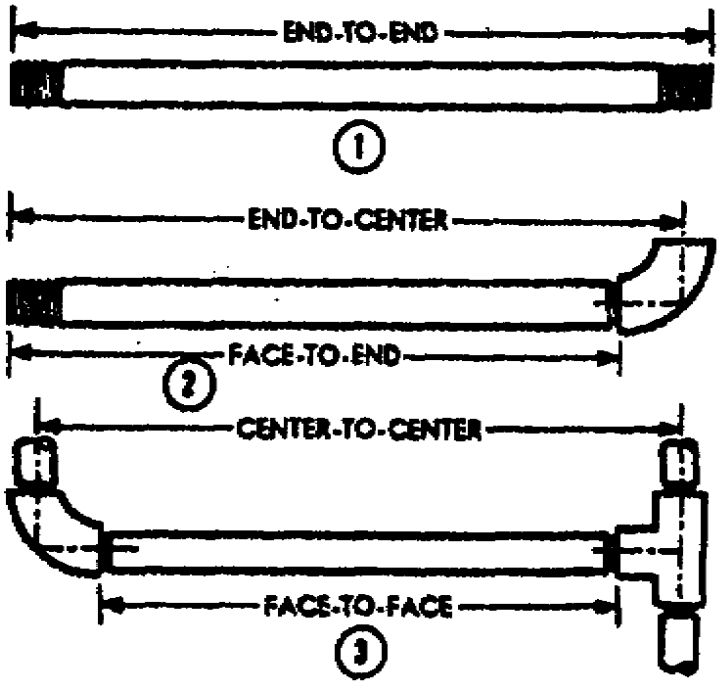


Figure 10. Threaded pipe measurements.

Size of pipe (inches)	Outside diameter (inches)	Number of threads per inch	Total length of threads (inches) (approx)	Effective length (inches) (approx)	Thread engagement (inches) (approx)
1/4	.54	18	5/8	3/8	3/8
3/8	.675	18	5/8	7/16	3/8
1/2	.840	14	13/16	9/16	1/2
3/4	1.05	14	13/16	9/16	1/2
1	1.315	11 1/2	1	11/16	9/16
1 1/4	1.660	11 1/2	1	11/16	5/8
1 1/2	1.9	11 1/2	1	3/4	5/8
2	2.375	11 1/2	1 1/16	3/4	11/16
2 1/2	2.875	8	1 9/16	1 1/8	15/16
3	3.5	8	1 5/8	1 3/16	1
4	4.5	8	1 3/4	1 5/16	1 1/16
5	5.560	8	1 13/16	1 3/8	1 3/16
6	6.625	8	1 15/16	1 1/2	1 1/4

Figure 11. Pipe thread data for standard pipe.

(1) End-to-end measure. End-to-end measure (1, fig 10) is the full length of the pipe including both threads.

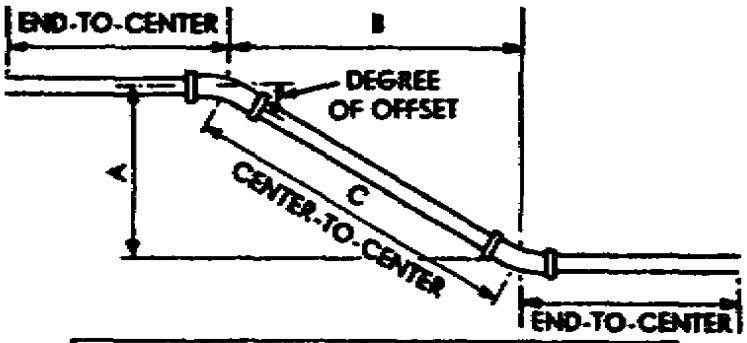
(2) End-to-center measure. End-to-center measure (2, fig 10) is used for a piece of pipe having a fitting screwed on one end only. The pipe length is equal to the measurement minus the end-to-center dimensions of the fitting plus the length of thread engagement.

(3) Face-to-end measure. Face-to-end measure (2, fig 10) is also used for a piece of pipe having a fitting screwed on one end only. The pipe length is equal to the measurement plus the length of thread engagement.

(4) Center-to-center measure. Center-to-center measure (3, fig 10) is used for a length of pipe which has fittings screwed on both ends. The pipe length is equal to the measurement minus the sum of the end-to-center dimensions of the fittings plus twice the length of thread engagement.

(5) Face-to-face measure. Face-to-face measure (3, fig 10) is used in the same situation as (4) above. The pipe length is equal to the measurement plus twice the length of thread engagement.

(6) Measuring offsets. Figure 12 and the following procedure explain how to run an offset. For example, a 45° offset with a 3-inch pipe is to be measured; the distance between the parallel runs A (center-to-center of pipe) is 40 inches. Then, from figure 12, distance C (center-to-center of the 45° elbows) is 40 times 1.4142, or about 56-9/16 inches. A standard 3-inch 450 elbow is 4-5/8 inches end-to-center and, from figure 11, requires a 1-inch thread engagement. Nine and one-quarter inches (2 x 4-5/8) are deducted and 2 inches for two thread engagements are added. This results in an end-to-end length of pipe of 49-5/16 inches.



DEGREE OF OFFSET	WHEN A = 1, B =	WHEN B = 1, A =	WHEN A = 1, C =
60°	0.5773	1.732	1.1547
45°	1.000	1.000	1.4142
30°	1.732	0.5773	2.0000
22½°	2.414	0.4142	2.6131
11¼°	5.027	0.1989	5.1258
5⅝°	10.168	0.0983	10.217

Figure 12. Pipe measurement for offsets.

b. Tubing. Copper tubing is measured in the same way as threaded pipe. Allowance is made for fitting dimensions (solder or compression type) and for the distance the tubing is inserted into the fitting. Offsets for rigid type tubing are determined in the same way as for threaded pipe. Since flexible tubing is easily bent, fittings for offsets are usually unnecessary.

EXERCISE

16. Which are the three strengths in which pipe is available?

a. Strong, extra strong, and double extra strong
b. Strong, medium strong, and regular
c. Regular, strong, and extra strong

17. Which type of copper tubing is mainly used in hot water systems?

a. K
b. L
c. M

18. Which type of copper fitting is most widely used?

a. Compression
b. Solder
c. Drain, waste, and vent

19. Which type valve uses a ball system to prevent reversal of flow in the line?

a. Stop valve
b. Angle valve
c. Check valve

20. Which measurement is used to measure a piece of pipe having a fitting screwed on one end only?

a. Face-to-end
b. Center-to-center
c. End-to-end

21. What would be the thread engagement for a 1-inch pipe?

a. 1/2 inch
b. 9/16 inch
c. 5/8 inch

6. BENDERS.

a. Copper and brass. Benders are designed to facilitate bending brass or copper pipe and tubing. Benders issued through the Army supply system are of the spring type sized to fit pipe and tubing ranging from 1/4 to 1 inch in diameter (fig 13). A tube bender is used to prevent tubing from kinking or flattening out at the desired bend. To use a bender, push it over the tube until the center of the bender is centered over the point in the tube where the bend is to be made. The tube can then be bent by hand to the desired radius. Pull the bender from the tube after bending.

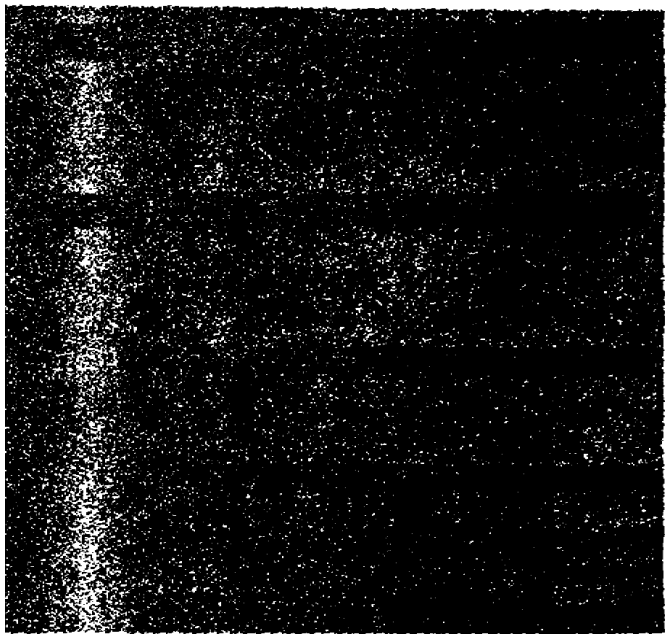


Figure 13. Hand pipe and tube benders.

b. Iron pipe.

(1) Basic considerations. At times it is more desirable to bend iron pipe than use additional fittings to change the direction of the pipeline. There are limits to the radius of bends and, generally, only smaller sizes of pipe are bent.

(2) Procedure.

(a) Smaller pipes are bent cold using only leverage. A hickey, which is a simple tool for bending pipe, is made by screwing a length of pipe to the side outlet of a T.

(b) Larger pipes are bent using bench tools and heat, the heat being applied to the inside of the bend. A bench tool (fig 14) may be made by drilling holes in a steel plate. Steel pins are placed in the holes to furnish the needed leverage.

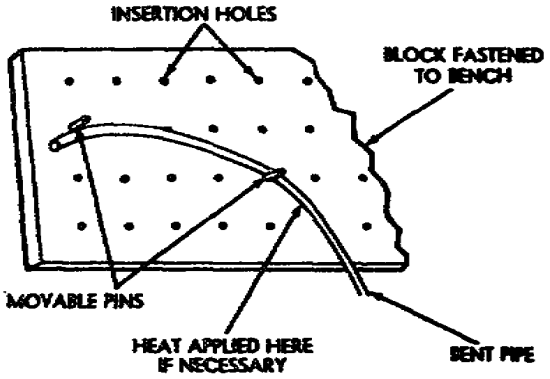


Figure 14. Bending block and pins.

(c) For offset bends, allowing a straight length between the bends is better than making a direct reverse bend.

(3) Bending radius. Figure 15 gives the radii for bending iron pipe of various sizes.

Size of pipe (inches)	Advisable radius (inches)	Minimum radius (inches)
⅛	2	1¼
¼	2⅛	1⅜
⅜	2½	1½
½	3¼	1¾
¾	4	2¼
	4½	2½
1	5	3
1¼	5¾	3¼
	7	4½
1½	15	10
	18	12
2	21	14
	24	16
2½	27	18
	30	20
	36	24

Figure 15. Radii for bending iron pipe.

7. PIPE VISE.

a. Introduction. The pipe vise is a tool used to hold pipe firmly during cutting, reaming, threading, and partial making-up operations. Only the hinged vise will be discussed here. It has a fixed toothed lower jaw and a movable toothed upper jaw.

b. Procedure for use.

(1) Release the pressure on the jaws of the vise (fig 16) by turning the handle counterclockwise.

(2) Release the locking lever by pulling outward on it and then open the vise by tilting the upper body to the side on its pivot.

(3) Lay the pipe in the vise on the V-shaped lower jaw. Support a long length of pipe extending from the vise on a sawhorse or similar support.

(4) Reverse step (2) by tilting the upper body back to the closed position. The lever automatically locks.

(5) Turn the handle clockwise until the V-shaped upper jaw presses on the pipe. Turn the handle just far enough to get a good grip on the pipe. Avoid turning it too hard and marking the pipe.

Note. - When working with polished or plated pipe, protect it from being scratched by the steel jaws on the vise. A pipe coupling, split lengthwise and lined with sheet lead, makes a good clamp to use in the vise with such pipe.

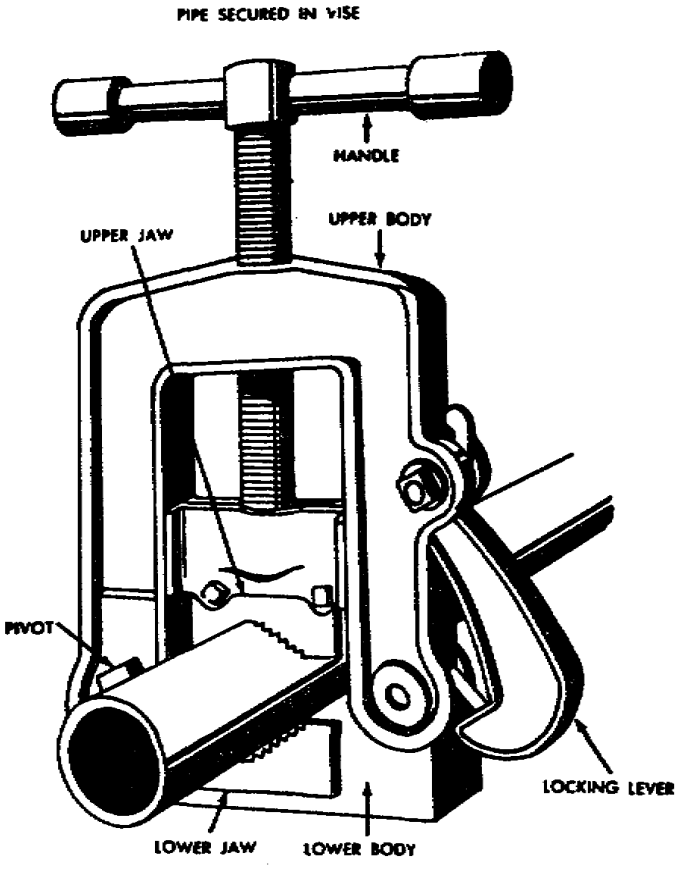


Figure 16. Pipe clamped in vise.

8. PIPE AND TUBE CUTTERS AND FLARING TOOLS.

a. Purpose of pipe and tube cutters and flaring tools. Pipe cutters (fig 17) are used to cut pipe made of steel, brass, copper, wrought iron, and lead. Tube cutters (fig 17) are used to cut tube made of iron, steel, brass, copper, and aluminum. The essential difference is that tubing has considerably thinner walls as compared to pipe. Flaring tools (fig 18) are used to make single or double flares in the ends of tubing.

b. Types of pipe and tube cutters and flaring tools.

(1) Pipe cutters. Two pipe cutters are issued: one has a cutting capacity of 1/8 to 2 inches and the other from 2 to 4 inches. The pipe cutter (fig 17) has a special alloy steel cutting wheel and two pressure rollers which are adjusted and tightened by turning the handle.

(2) Tube cutters. Some types of tube cutters closely resemble pipe cutters, except that they are of lighter construction. A hand screw feed tubing cutter of 1/8-inch to 1-1/4-inch capacity (fig 17) has two rollers with cutouts located off center so that cracked flares may be held in them and cut off without waste of tubing. It also has a retractable reamer blade that is adjusted by turning a knob. Other types of tube cutters shown are designed to cut tubing up to and including 3/4 and 1 inch o.d. Some cutters have the feed screw covered to protect the threads against dirt and damage.

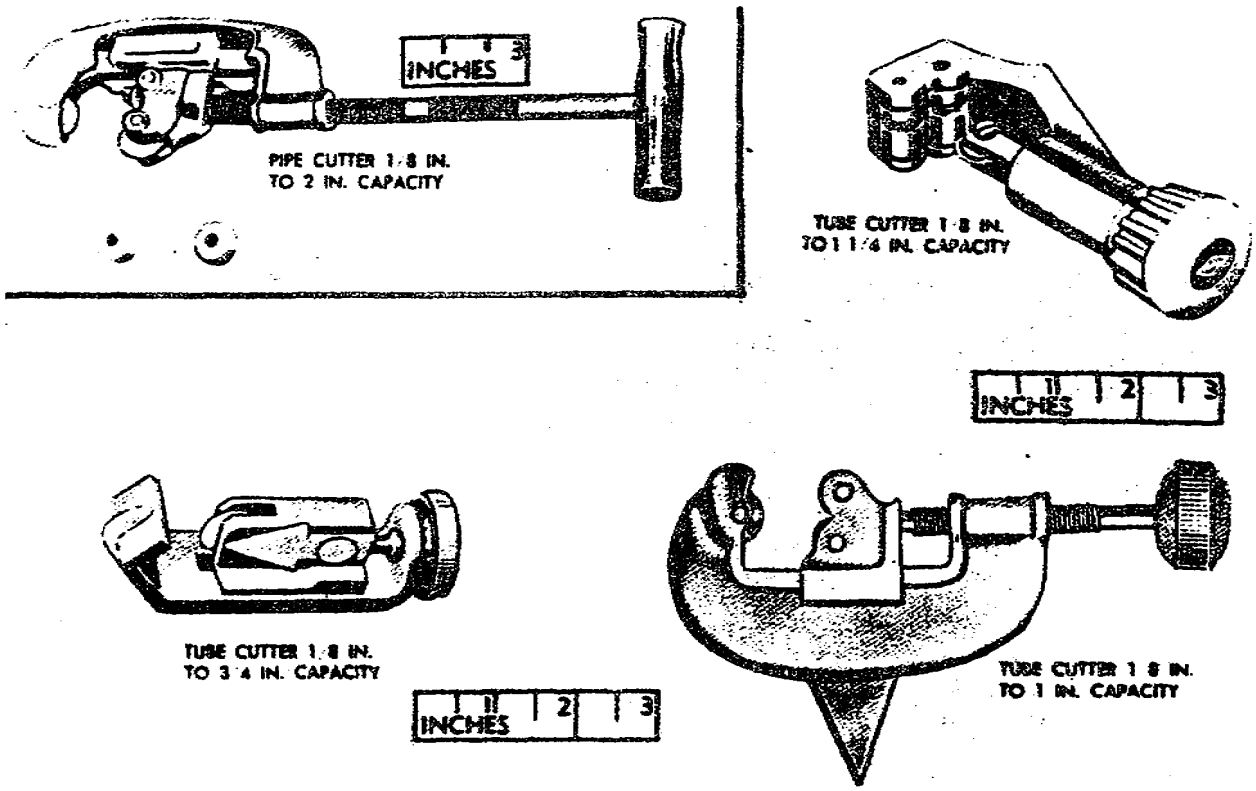


Figure 17. Pipe and tube cutters.

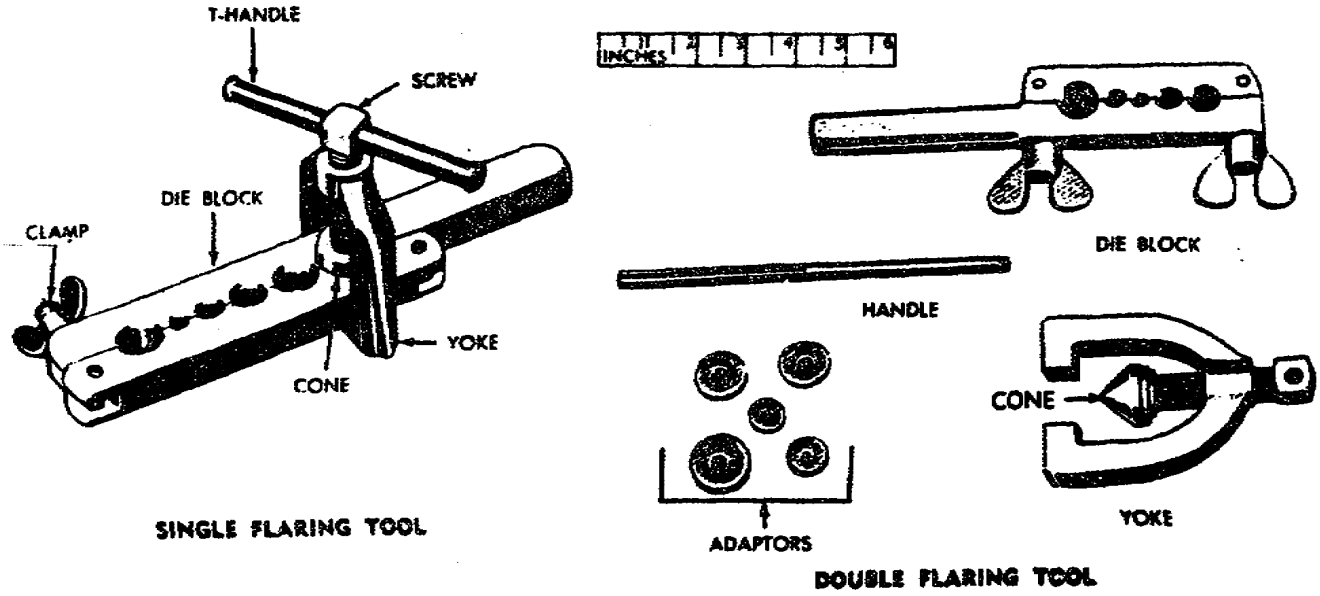


Figure 18. Flaring tools.

(3) Flaring tools. Flaring tools (fig 18) are used to flare soft copper, brass, or aluminum to make up 45° flare joints. The single flaring tool consists of a split die block that has holes for 3/16-, 1/4-, 5/16-, 3/8-, 7/16-, and 1/2-inch o.d. tubing, a clamp to lock the tube in the die block, a yoke that slips over the die block that has a compressor screw, and a cone that forms a 45° flare or a bell shape on the end of the tube. The screw has a T-handle. A double flaring tool has the additional feature of adapters that turn in the edge of the tube before a regular 45° double flare is made. It consists of a die block with holes for 3/16-, 1/4-, 5/16-, 3/8-, and 1/2-inch tubing, a yoke with a screw and a flaring cone, plus five adapters for different size tubing all carried in a metal case.

c. Use of pipe cutters. Before cutting pipe, make certain the required correct length is determined.

(1) Mark the spot where the cut is to be made with a scriber, file, chalk, or crayon.

(2) Lock the pipe tightly in the vise with the cutting mark approximately 8 inches from the vise. This distance will vary according to the space required by the die stock to be used for threading.

(3) Open the jaws of the pipe cutter by turning the handle counterclockwise.

(4) Place the cutter around the pipe from underneath (fig 19) with the cutting wheel (single-wheel cutter) exactly on the mark. The rollers of the single-wheel cutter insure a straight cut. If a three-wheel cutter is used, place the cutting wheel of the movable jaw on the mark and make sure that all three wheels lie level at right angles to the centerline of the pipe.

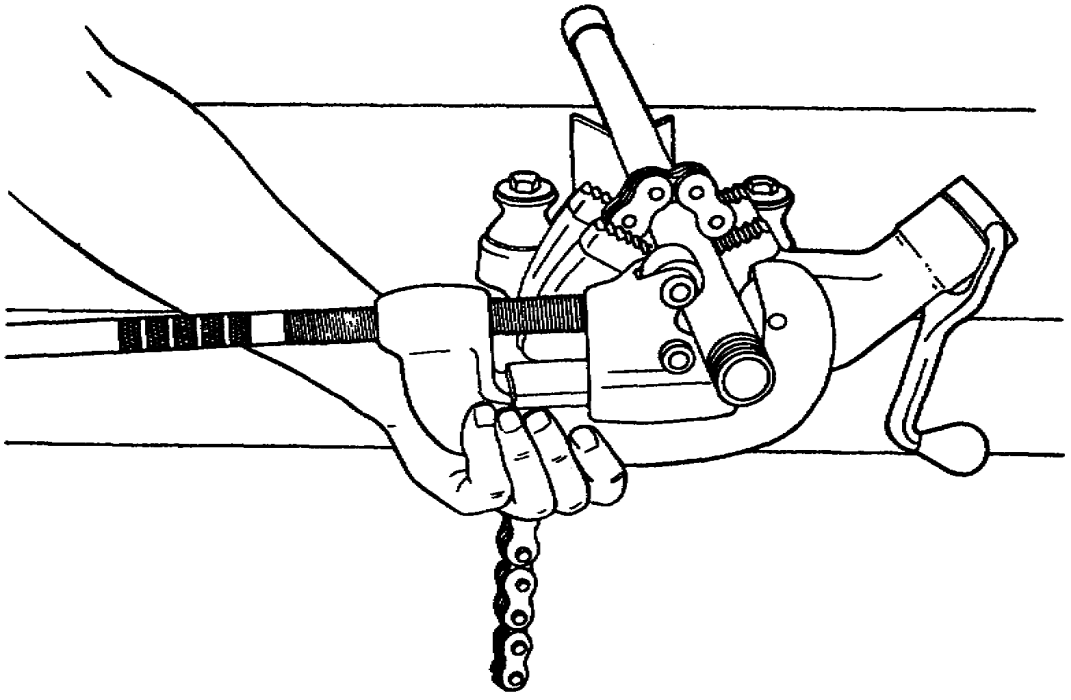


Figure 19. Cutting pipe.

(5) Close the jaws lightly against the pipe by turning the handle clockwise.

(6) After the wheel(s) and rollers have just made contact with the pipe, make another clockwise quarter turn on the handle. This gives the wheel(s) a "bite" on the pipe. Apply thread cutting oil to the wheel(s) and pipe.

(7) Rotate the cutter completely around the pipe, making a quarter turn on the handle for each complete revolution, until the pipe is cut.

(8) If the pipe has been cut with a three-wheel cutter, the outside bur must be removed with a file before the pipe can be threaded.

d. Use of tube cutters. Both rigid and flexible copper tubing may be cut with a tubing cutter or a hacksaw. Follow the procedure for cutting iron pipe when using the pipe cutter; generally, no vise is required to hold the tubing. One hand holds the tubing firmly while the other turns the cutter. A vise may be needed to cut tubing of large diameter, in which case care must be taken to avoid crushing the tubing. An iron pipe coupling sawed in half and lined with sheet lead can be placed around the pipe to protect it while it is held in the vise. If a hacksaw is used, it should have a fine-toothed blade (24 teeth per inch). A miter box or jig, made from a piece of wood 2 to 4 inches long (fig 20), will help to keep the cut square. After cutting, remove all burs by reaming.

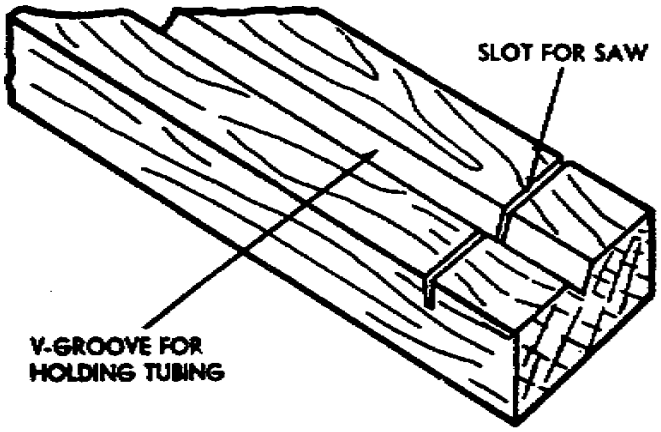


Figure 20. Jig for cutting tubing with a hacksaw.

e. Flaring tools. Compression-type fittings have threaded flange nuts which compress the flared end of the flexible tubing against a ground joint on the fitting. Follow the steps below to make a good joint.

(1) Inspect the end of the tubing to see that it has no burs and is not badly out-of-round. Flaring will generally re-round tubing that is slightly out-of-round.

(2) Remove a flange nut from the fitting and slide it onto the tubing unthreaded end first.

(3) Flare the end of the tubing with either a flaring tool or a flanging tool. Put a drop or two of light machine oil on the end of the tubing when flaring it.

(a) When using the flanging tool (fig 21). hold the tubing in the hand; do not rest the opposite end on a solid object as this may damage the tubing. Keep the tool centered and straight, and tap it into the tubing until the flare fills the recess in the flange nut.

(b) When using the two-piece flaring tool (fig 21), place the tubing in the proper size hole with the tubing end level with the surface of the tool. Turn down the cone on the yoke until the flare on the tubing fills the beveled portion of the hole.

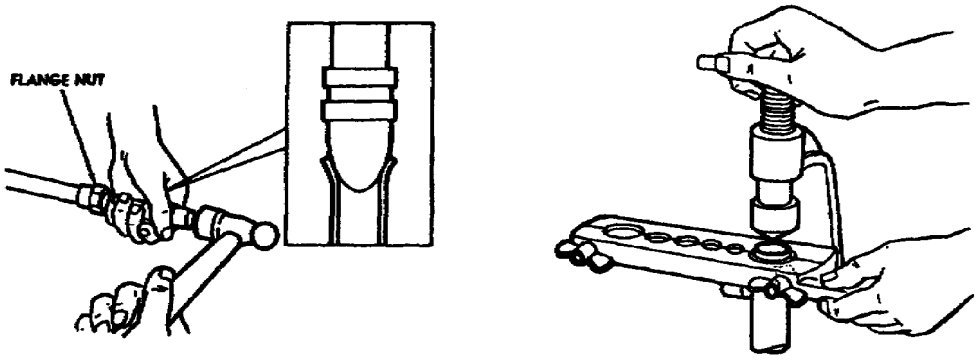


Figure 21. Using the flaring tool.

(4) Join the flared end of the tubing to the ground joint on the fitting and inspect for proper fit.

(5) Slide the nut back up to the flared end of the tubing (fig 22) and screw it on the male thread of the fitting until it is tight;

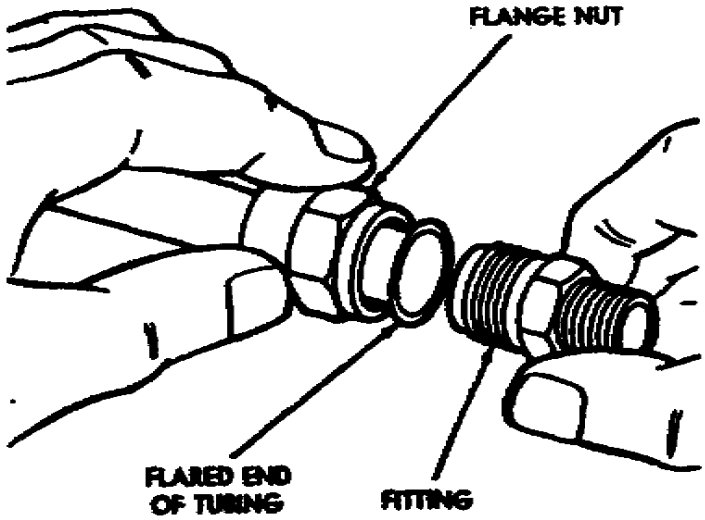


Figure 22. Making up a flared fitting.

(6) Finish making the connection by tightening the nut with wrenches (open or monkey), one on the nut and the other on the fitting. Never use one wrench alone; if the fitting is not held in place with a second wrench, it will turn and may spoil the connection at the other end.

9. REAMERS.

a. Purpose of reamers. Reamers are used to smoothly enlarge drilled holes to an exact size and to finish the hole at the same time. Reamers are also used to remove burs from the inside diameters of pipe and drilled holes.

b. Types of reamers.

(1) Solid straight hole reamers. Solid straight hole reamers (fig 23) are made of one solid piece of high speed steel having a straight shank and straight or spiral flutes. The cutting edges or lands between the flutes are usually evenly spaced. However, some solid reamers have irregularly spaced lands to prevent the tool from chattering. Solid straight shank, straight flute reamers are issued in sizes from 1/16 inch up to and including 3 inches in diameter. These reamers are also issued in sets encased in a wood or metal box containing 25 reamers sized from 1/8 to 1/2 inch and progressing by 1/64-inch increments. Other reamer sets include solid taper pin reamers in addition to the solid straight hole reamers. Each reamer size is stamped on the shank of the tool.

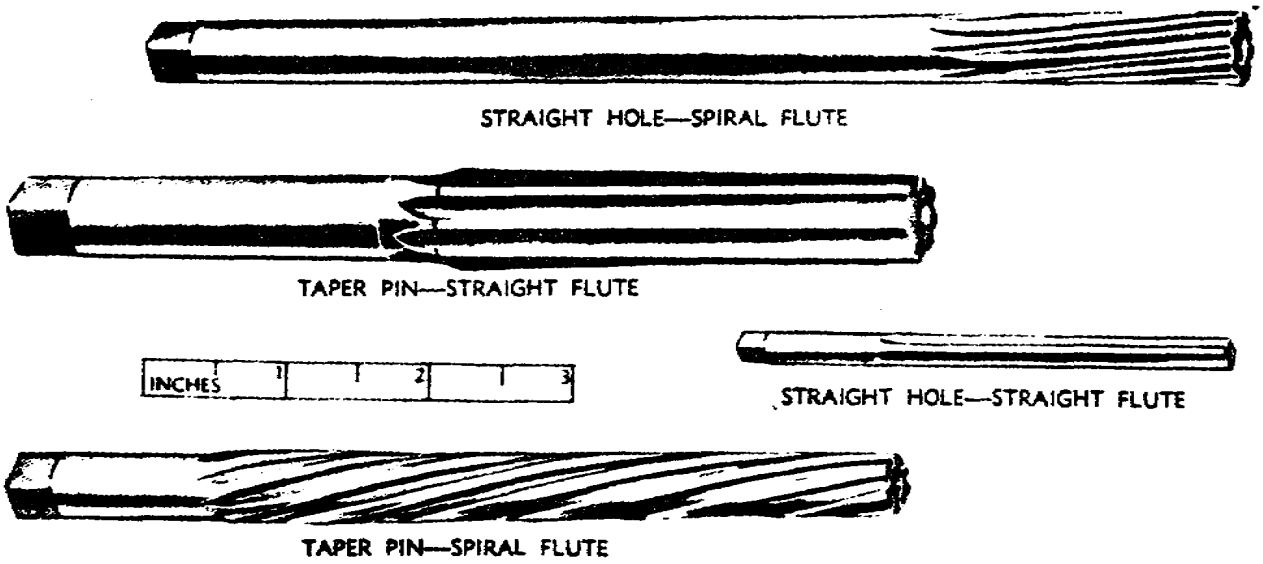


Figure 23. Solid straight hole and taper pin reamers.

(2) Solid taper pin reamers. Solid taper pin reamers (fig 23) are used to finish tapered holes for the insertion of tapered pins or other tapered parts. They are made with a standard taper of 1/4 inch per foot. Solid taper pin reamers are issued with straight or spiral flutes in sizes ranging from Nos 5/0 to 14, with diameters at the large end of the reamer ranging from 0.0984 to 1.5412 inches. These reamers are also issued in sets of 10 reamers--Nos 3/0 to 7--and a set of 11 reamers--Nos 0 to 10. As mentioned above, they are also included in mixed sets of both straight hole and taper pin reamers,

(3) Expansion reamers. Expansion reamers (fig 24) are adjustable and their sizes may be changed by 0.125 inch (1/8 inch) for a 1-inch reamer and by 0.3125 inch (5/16 inch) for a 2-inch reamer. The expansion reamer is made of carbon steel and has longitudinal cuts in some of its flutes. It is hollowed out and threaded to receive a tapered screw plug. The diameter of the reamer is changed by screwing in or backing out the screw plug. These reamers are issued with spiral flutes in two sizes--19/32-and 1-1/4-inch diameters. A straight flute with a floating pilot, having a range of 1/2 to 17/32 inch and having a length of 9 inches, is also issued.

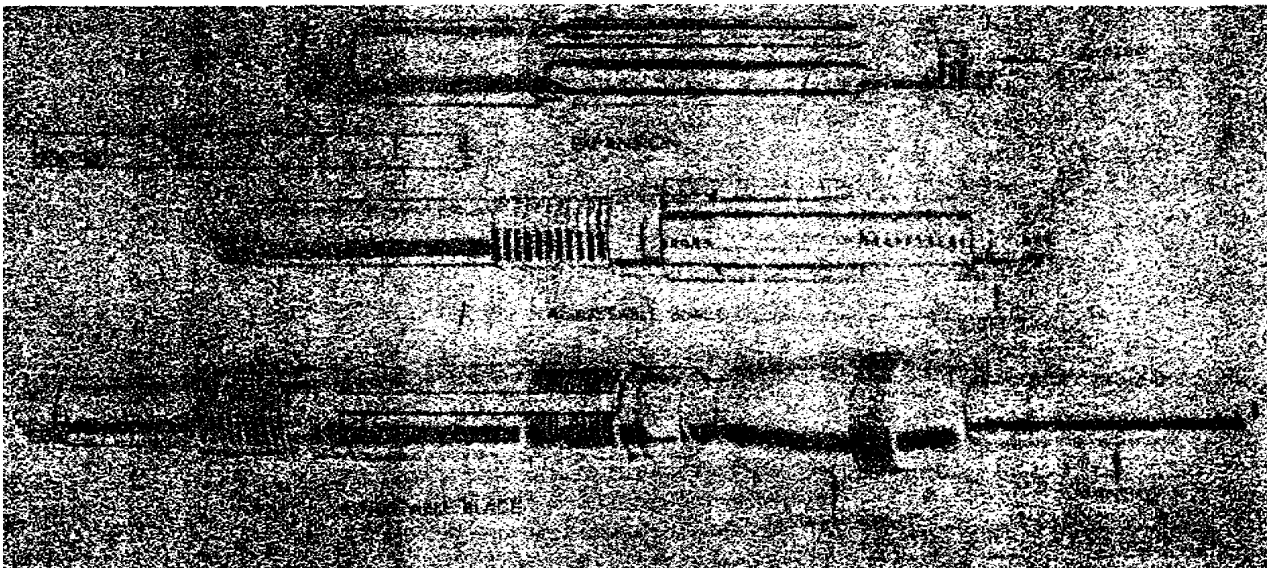


Figure 24. Adjustable reamers.

(4) Adjustable blade reamers. The blades of an adjustable reamer (fig 24) are separate from the body and are fitted into grooves in the threaded shank of the tool. Adjusting nuts below and above the blades control the diameter of the reamer. These reamers are issued with straight or spiral flutes, with or without a floating pilot, in several sizes. Spiral flute adjustable reamers are issued in sizes from 0.730- to 0.780-inch range up to 0.980- to 1. 030-inch range. Straight flute adjustable reamers are issued in sizes from a 1/2-to 9/16-inch range up to a 15/16- to 1-inch range in steps of 1/16 inch. They are also issued in steps of 1/16 inch from a 15/32- to 17/32-inch range up to a 1-25/32- to 2-3/32-inch range. Adjustable reamers are available in sets. One set contains five spiral flute reamers with floating pilots on solid mandrels ranging from 0.730 to 1.030 inches. Another set of the same type contains eight straight flute reamers ranging in size from 1/2 to 1 inch. Two other sets have reamers with lettered sizes A to H and A to K, 15/32- to 1-1/16-inch range and 15/32- to 1-17/32-inch range, respectively. The latter two sets do not have floating pilots or mandrels.

(5) Pipe reamers. Pipe reamers (fig 25) are made of carbon steel, are tapered, and have straight or spiral flutes. They are issued in three sizes: 1/8- to 1-inch pipe capacity, 1/4- to 1-1/4-inch pipe capacity, and 1/4- to 2-inch pipe capacity. Most pipe reamers are designed to receive a T-handle.

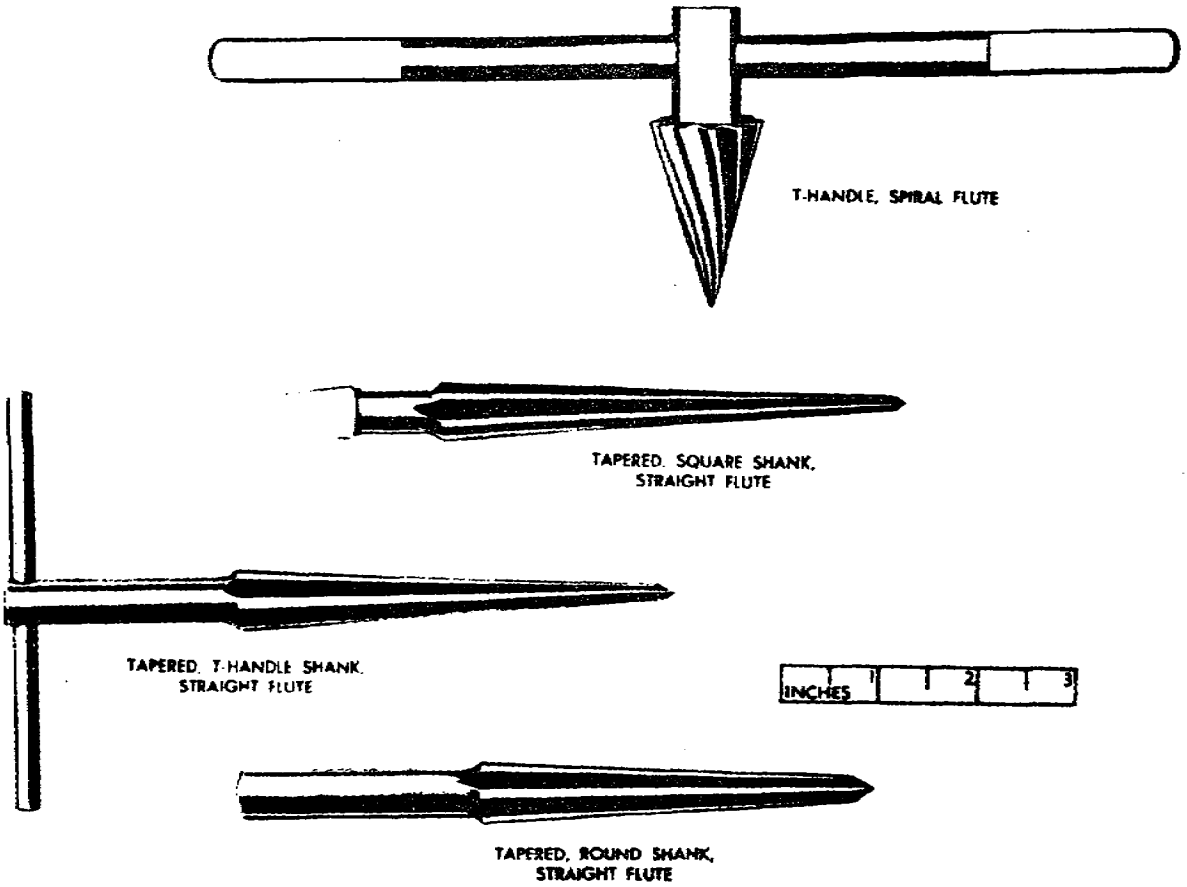


Figure 25. Pipe reamers.

c. Use of reamers.

(1) General.

(a) Use a solid straight hole reamer for most work, since it is the most accurate and rugged of the straight hole reamers.

(b) When using a taper pin, expansion, or adjustable reamer, a series of small cuts should be taken rather than one deep cut. Check the hole for size after each cut to insure that you do not remove too much metal from the hole.

(c) Never force a small reamer into a hole with too much pressure, since reamers are delicate and easily broken.

(d) Most reamers are hand-driven tools; however, some are power- driven.

(2) Straight hole reamers. A hand reamer is turned by means of a tap wrench that is tightened on the square end of the reamer shank. Secure the work in a vise so that the hole to be reamed is perpendicular to the top of the vise jaws. Position the reamer at the top of the hole (fig 26). Straight hole reamers have a slight taper at the end so that they will fit into the hole easily. Turn the wrench clockwise very slowly until the reamer is centered in the hole (fig 27).

CAUTION: Do not turn the wrench counterclockwise at any time. To do so will cause the tool to become dull, fail to cut, and become useless.

After centering the reamer, turn the wrench clockwise with a steady firm pressure until the reamer has been turned all the way through the hole. When reaming steel. use cutting oil or machine oil to lubricate the tool. When reaming soft iron, do not lubricate the tool. To remove reamer from hole, turn wrench clockwise and raise reamer simultaneously.

Note. - Turning the wrench too fast or too slowly will cause the reamer to chatter, producing an unevenly reamed hole.

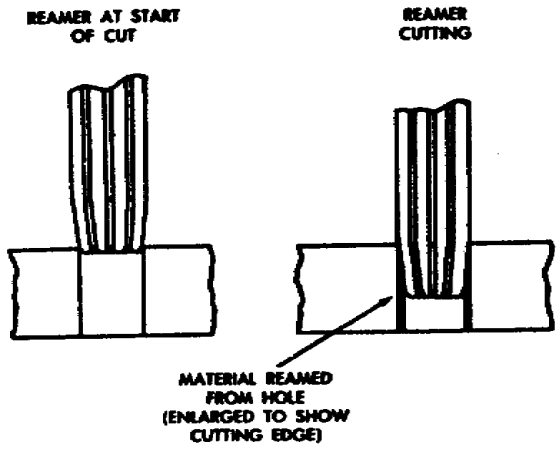


Figure 26. Reaming operation.

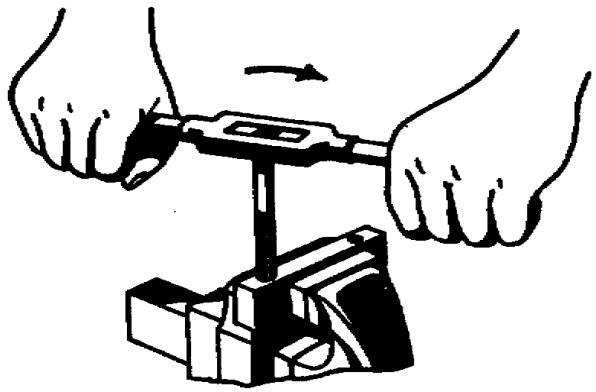


Figure 27. Use of tap wrench with reamer.

(3) Taper pin reamers. Before using a taper pin reamer be certain that the hole is the right size, generally just large enough to allow about 1/2 inch of the reamer's length to go into it. The drill used to make the hole must be the largest possible size that will allow the reamer to clean up the hole along its entire depth. Keep the reamer as straight as possible and ream hole as discussed above. To prevent damage to the walls of the hole, remove the reamer frequently and brush away the metal chips that stick to the flutes.

(4) Pipe reamers. Before using a pipe reamer (fig 28), inspect the flutes to see if they are sharp and even and free from nicks or burs. Insert the point of the reamer into the pipe and push firmly. Rotate the handle of the reamer clockwise in short even strokes until the burs inside the cut piece of pipe are completely removed. Remove the reamer from the pipe by rotating it clockwise and removing it simultaneously.

Note. - The pipe must be secured in a pipe vise during this bur removing operation.

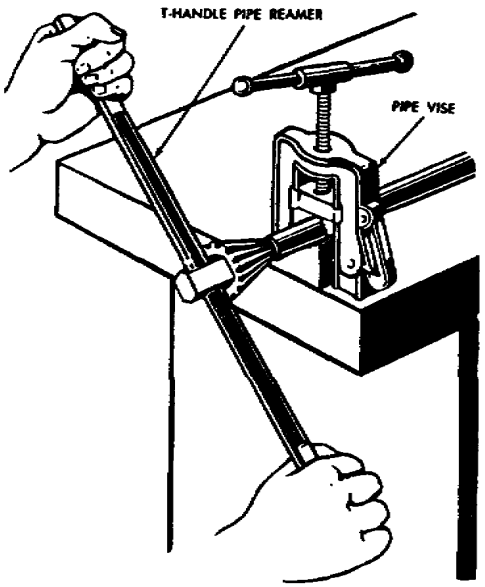


Figure 28. Removing bur from cut pipe.

10. THREADING.

a. Purpose of taps and dies. Taps and dies are used to cut threads in metal, plastics, or hard rubber. The taps are used for cutting internal threads and the dies are used to cut external threads.

b. Types of taps. There are several types of taps issued by the supply system. However, the most common are the taper, plug, bottoming, and pipe taps (fig 29). Special purpose taps (fig 30) such as mud or washout taps, boiler taps, and staybolt taps are also discussed in this paragraph.

(1) Taper hand tap. The taper or starting hand tap (fig 29) has a chamfer length of 8 to 10 threads. These taps are used when starting the tapping operation and tapping coarse threads in through holes especially in harder metals.

(2) Plug hand taps. Plug hand taps (fig 29) are designed for use after the taper tap and in through holes when tapping softer metals or fine-pitch threads. They have a chamfered length of 3 to 5 threads. These taps. are the most popular.

(3) Bottoming hand taps. Bottoming hand taps (fig 29) are used for threading the bottom of a blind hole. They have a very short chamfer length of only 1 to 1-1/2 threads for this purpose. This tap is always used after the plug tap has already been used and for hard materials. Both the taper hand and plug hand taps should precede the use of the bottoming hand tap.

(4) Pipe taps. A taper pipe tap (fig 29) is used for pipe fittings and on other places where extremely tight fits are necessary. The tap diameter, from end to end of threaded portion, increases at the rate of 3/4 inch per foot. All threads on this tap cut as compared to the straight taps where only the nonchamfered portion does the cutting.

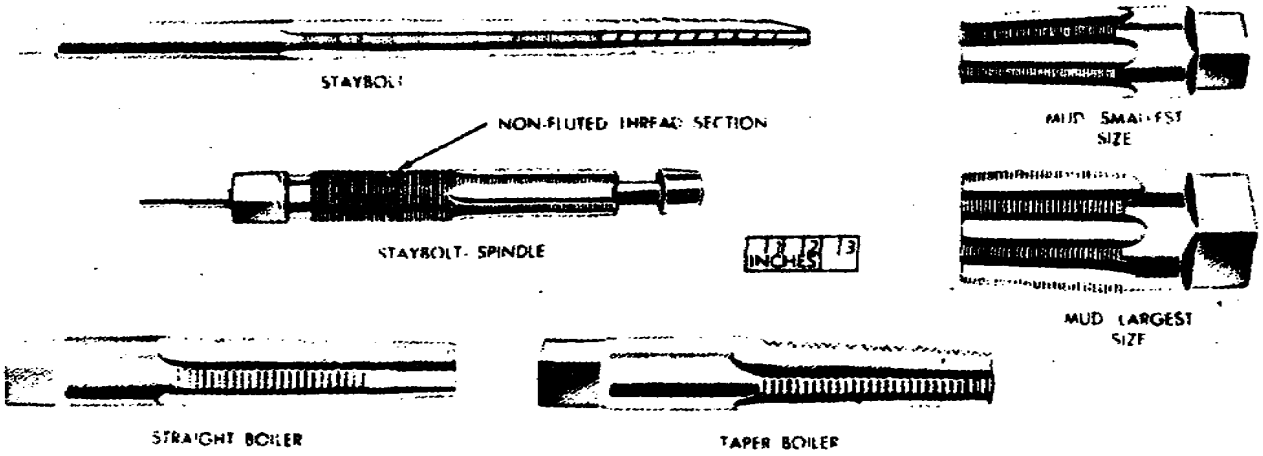


Figure 29. Types of common taps.

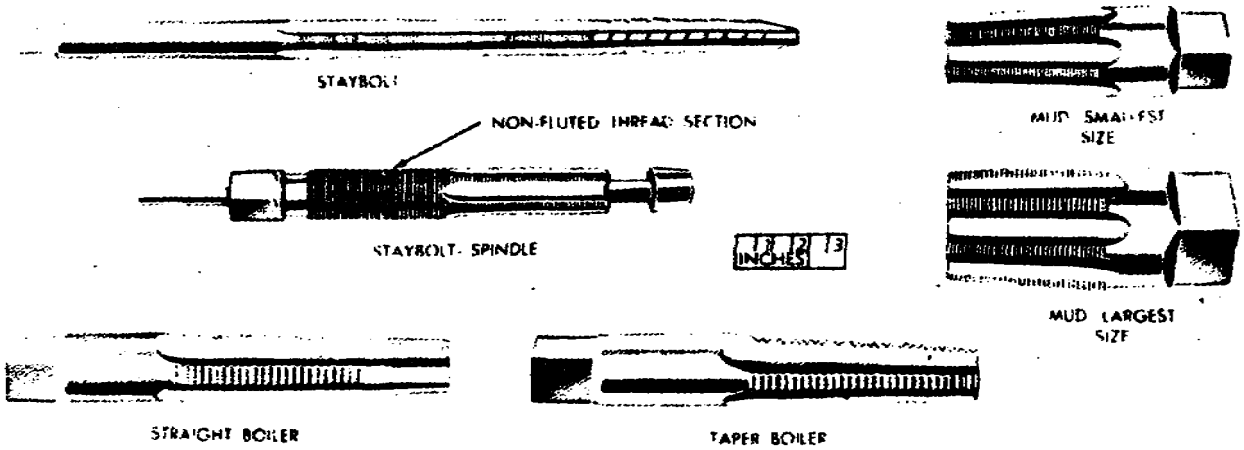


Figure 30. Special purpose taps.

(5) Boiler taps. Straight boiler taps (fig 30) range in diameter from 1/2 to 1-1/2 inches, The chamfered portion of the thread simplifies starting. Taper boiler taps have no chamfered portion and the threaded portion is tapered 3/4 inch per foot. The overall and shank diameters are similar to those of straight boiler taps.

(6) Staybolt taps. Staybolt taps (fig 30) are used principally in boiler locomotive and railroad shops for tapping the staybolt holes in the outer and inner plates or shells of boilers.

(7) Mud or washout taps. Mud or washout taps (fig 30) have 6 flutes with a 1-1/4-inch taper per foot and 12 threads per inch. They are used to cut special American National or V-form threads when tapping mud plug drain holes.

(8) Fusible plug tap. The fusible plug tap (not illustrated) is made of carbon steel and has a 1-1/4-inch taper per foot. It has a thread length of 4-3/8 inches, is 1-inch square on the shank, has 4 flutes, and is 7 inches long.

(9) Pipe tap and drill. A pipe tap and drill (not-illustrated) is a combination twist drill and tap. The tap portion follows the twist drill tip. The tool does drilling and tapping in one operation. They are made of carbon steel with a tapered square shank and sized to drill and tap holes 1/4--18, 3/8--18, and 1/2--14.

c. Types of dies. Dies are made in several different shapes and are of the solid or adjustable type.

(1) Solid dies.

(a) Square pipe dies. The square pipe die (fig 31) will cut American Standard Pipe Thread only. It is issued in sizes that will cut threads on pipe from 1/8--27 to 3-8.

(b) Rethreading dies. A rethreading die (fig 31) is used principally for dressing over bruised or rusty threads on screws and bolts. However, it may be used for cutting occasional new threads. It is available in a variety of sizes for rethreading American Standard Coarse and Fine threads. These dies are usually hexagon in shape and can be turned with a socket, box, open-end, or any wrench that will fit. Rethreading dies are available in sets of 6, 10, 14, and 28 assorted sizes in a case.

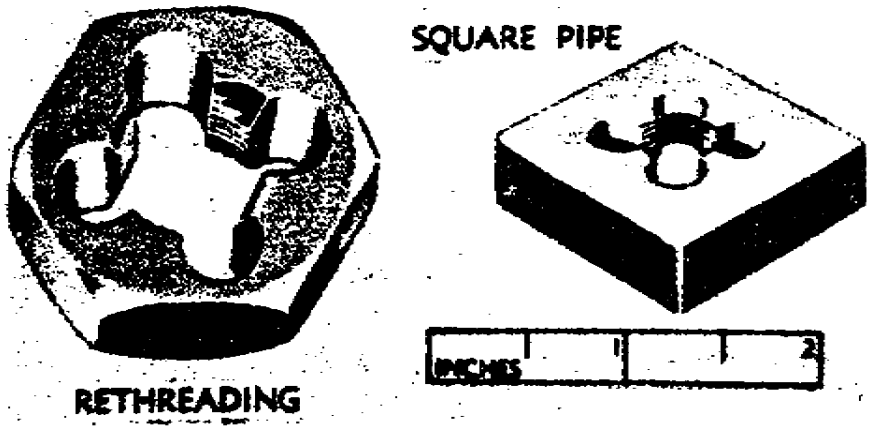


Figure 31. Types of solid dies.

(2) Adjustable dies.

(a) Round split adjustable dies. Round split adjustable dies (fig 32) are called "Button" dies and can be used in either hand diestocks or machine holders. The adjustment in the screw adjusting type is made by a fine-pitch screw which forces the sides of the die apart or allows them to spring together. The adjustment in the open adjusting types is made by means of three screws in the holder--one for expanding and two for compressing the dies. Round split adjustable dies are available in a variety of sizes to cut American Standard Coarse and Fine threads, special form threads, and for the standard sizes used in Britain and other European countries. For hand threading, these dies are held in diestocks (fig 33). One type has three pointed screws that will hold round dies of any construction, although specifically made for open adjusting-type dies.

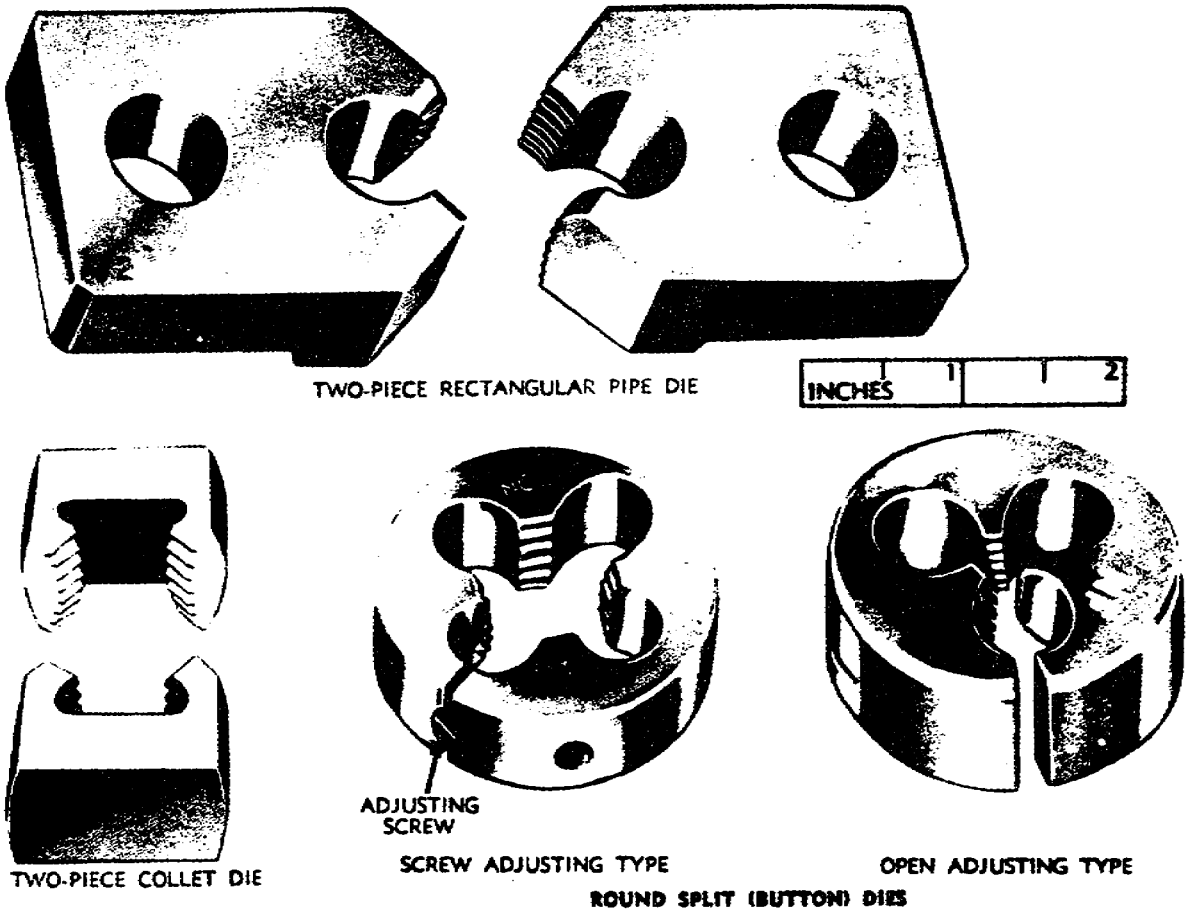


Figure 32,. Types of adjustable dies.

(b) Two-piece collet dies. A two-piece collet die (fig 32) is used with a collet (fig 33). The collet consists of a cap and guide. The die halves are placed in the cap slot and are held in place by the guide which screws into the underside of the cap. The die is adjusted by means of setscrews at either end of the internal slot. This type of adjustable die is issued in various sizes to cover the cutting range of American Standard Coarse and Fine and special form threads. Diestocks (fig 33) to hold collets are issued in three sizes.

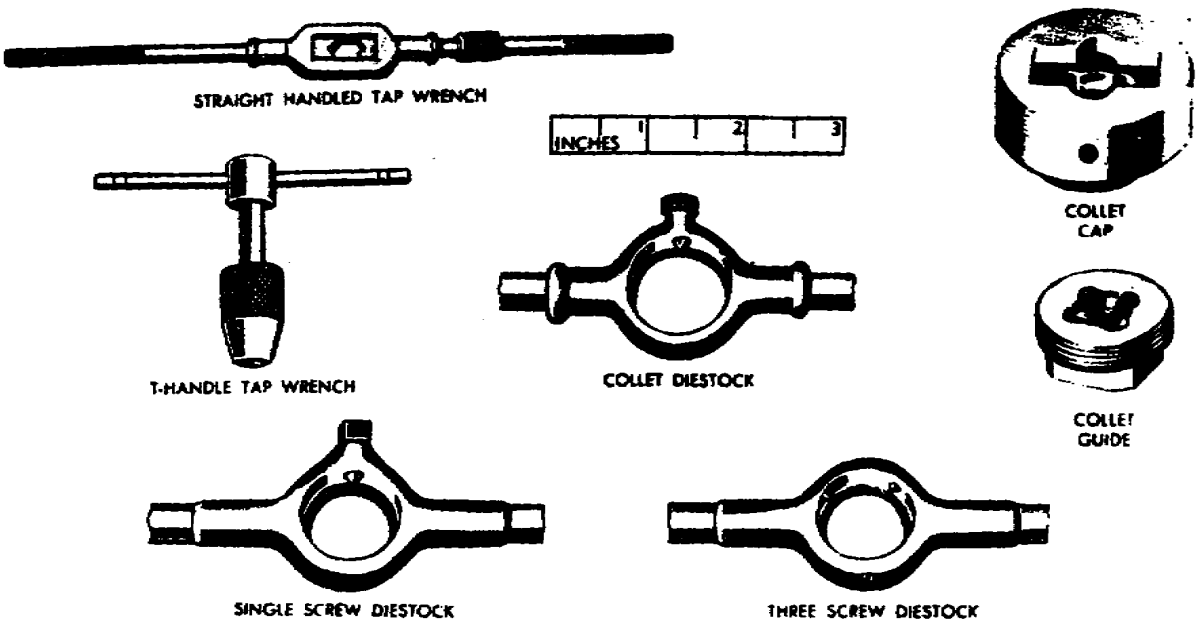


Figure 33. Diestocks, die collet, and tap wrenches.

(c) Two-piece rectangular pipe dies. Two-piece rectangular pipe dies (fig 32) are available to cut American Standard Pipe Threads. They are held in ordinary or ratchet-type die-stock. The jaws of the dies are adjusted by means of setscrews. An adjustable guide serves to keep the pipe in alinement with respect to the dies. The smooth jaws of the guide are adjusted by means of a cam plate; a thumbscrew locks the jaws firmly in the desired position (fig 34). Non-ratchet-type diestock and plain guides are also available for pipe threading (fig 35).

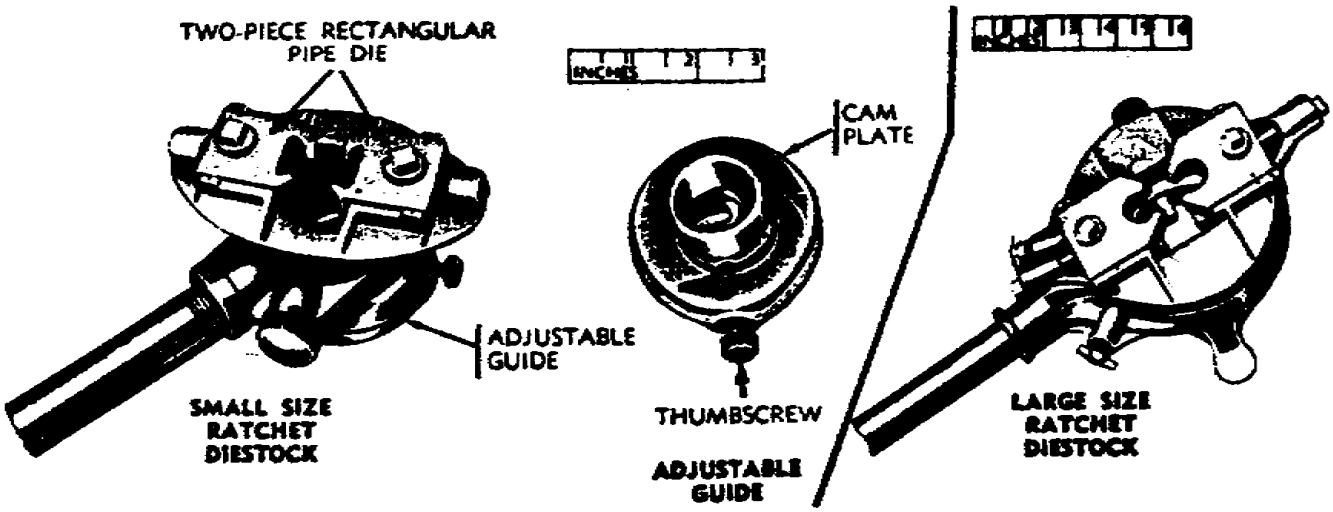
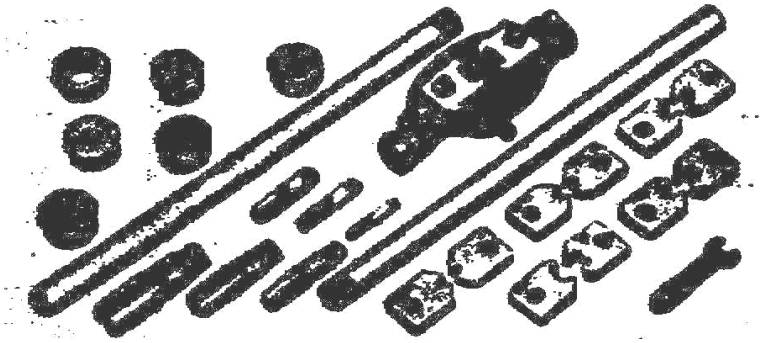


Figure 34. Adjustable die guide and ratchet diestocks.



THE THREADING SET WITH RECTANGULAR ADJUSTABLE DIES, DIESTOCK, WRENCH, GUIDES AND TAPS.

BOLT AND SCREW THREADING SET WITH ROUND ADJUSTABLE SPLIT DIES, DIESTOCKS, TAPS, TAP WRENCHES, AND SCREWDRIVERS.

Figure 35. Threading sets.

d. Use of taps.

(1) Selecting a tap drill. The size of a tap is the outside diameter of its threads; therefore, theoretically the hole drilled for tapping could be smaller than the tap by twice the depth of the thread if a full thread is cut. The shape of the thread partly determines the amount to be subtracted from the tap diameter. Do not use a tap drill that is too small in diameter, as this will cause tapping troubles. A drilled hole should be of sufficient diameter to produce a thread depth of approximately 75 percent. This 75 percent is only an average. Actually, the percentage may vary from 50 to 53 percent for small or deep holes to a maximum of 83 percent on any size. A definite thread depth for all sizes, under all conditions, is not practical. You must determine which is most suitable by analyzing the following conditions: diameter of tapped hole, nature of material being tapped, depth of tapped hole, and the pitch.

(a) Diameter and pitch of tapped hole. The coarser the pitch, the larger is the thread depth if a full thread were cut. Try a drill giving 75 percent thread depth first. If tap breakage results, reduce the thread depth gradually by using larger drills until satisfactory performance is obtained.

Note. - A nut with only 50 percent thread depth will break the bolt before it strips the thread.

American Standard screw threads are standardized in two series: coarse and fine. As a tap size becomes smaller, the percentage of double thread depth in relation to basic major diameter of the screw generally becomes larger.

Basic major diameter	% Double thread depth Coarse	Fine
1.0 inch	16	9
0.750 inch	17	11
0.500 inch	20	13
0.375 inch	22	14
0.250 inch	26	19
No 5 machine screw	26	24

(b) Nature of material being tapped. Soft metals such as copper, aluminum, monel metal, nickel silver, and the low melting point alloys have a tendency to flow toward the root of the minor diameter of the tap while being tapped. The minor diameter of tapped holes in such material will be smaller after tapping. Take this into consideration when selecting the tap drill of sufficient size. Use the smallest thread depth possible on materials that are very tough or of high hardness. This is accomplished by using the largest drill possible, which nevertheless will be smaller than the one used for softer materials under similar circumstances.

(c) Depth of tapped hole. Larger tap drills giving 50 percent thread depth may be used when holes are deeper than 1-1/2 times the tap diameter. Punched holes often cause binding and tap breakage, especially in thin sheet metal, which creates an "oilcan" effect. When the hole is punched, the metal is flared out. As the tap is reversed after threading, it draws in this flare and binds. Consider this when selecting punch size. The larger the punched hole, the less tendency for the tap to bind. Holes formed in castings and forgings should be checked for 75 percent depth and reamed to size, if necessary, before tapping.

(2) Tapping a hole.

(a) After the proper size and type hole (fig 36) is drilled and cleaned, secure the tap in a tap wrench.

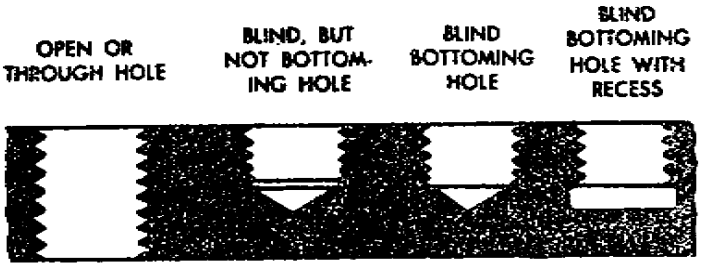


Figure 36. Types of drilled holes.

(b) Apply cutting oil to the tap and to the hole. Place the point of the tap in the hole and rotate the tap (fig 37) clockwise for right-hand threads and counterclockwise for left-hand threads.

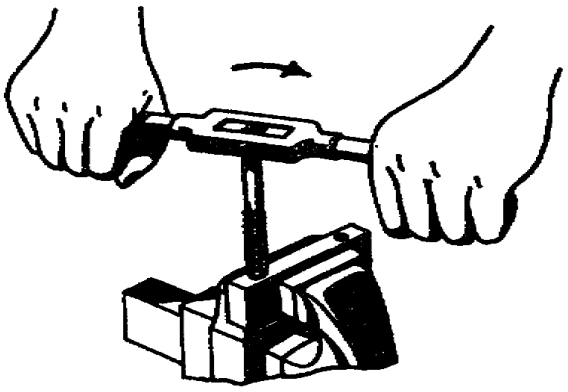


Figure 37. Using a tap and tap wrench.

(c) Check the tap for straightness in the hole by using a square (fig 38). Check to see that the tap is in line with the axis of the hole and at right angles to the face of the work. Check at more than one position around the tap.

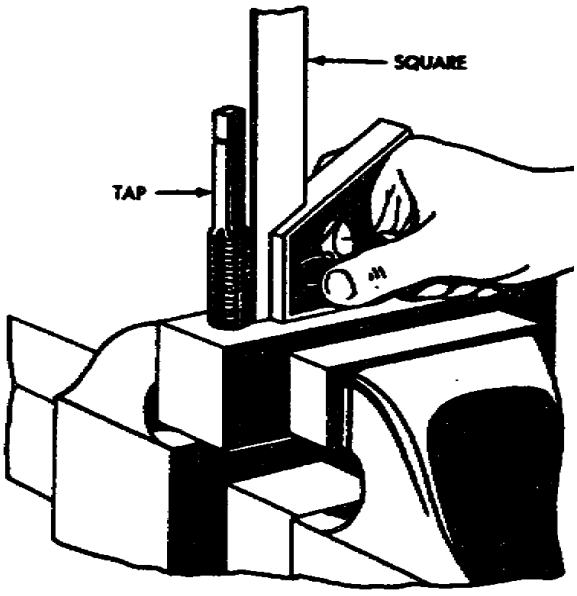


Figure 38. Checking tap for straightness.

(d) It is not necessary to feed the tap into the hole with any pressure as the threads will pull it in at the proper rate. Keep the tap straight.

(e) When tapping rough material, after each half turn of the tap in a forward or cutting direction, rotate the tap a quarter turn back, then a half turn forward, then a quarter turn back, etc, until the hole is tapped. Use pure lard cutting oil to keep the tap well lubricated when tapping.

(f) If the hole to be tapped is a blind hole (fig 36), use a plug tap and finally a bottoming tap (fig 39) to complete the tapping operation. A bottoming hole is one in which the thread has been tapped as far as the bottom. Use extreme caution to keep the taps from being forced against the bottom of the hole. Check cut threads with the proper screw pitch gage.

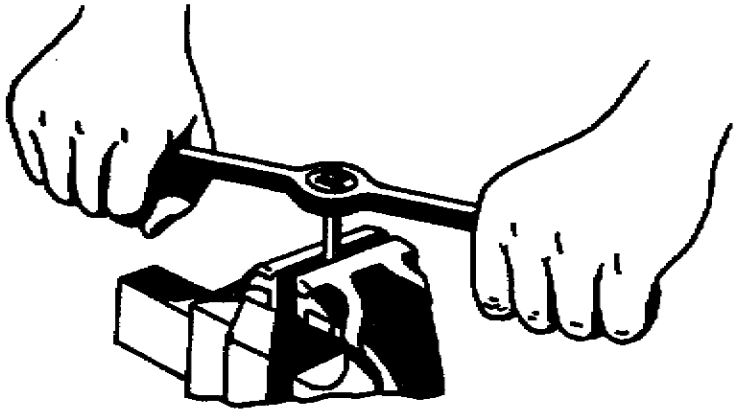


Figure 39. Using a die and diestock.

e. Use of dies.

(1) General. The general procedure for cutting threads by hand is described below.

(a) Make certain the work to be threaded is clean and free from burs.

(b) Secure the work firmly in a vise (fig 39).

(c) See that the die is held firmly in the diestock. Set an adjustable die to the desired size before securing it in the diestock.

(d) Drop some cutting oil on the work and the die and position the chamfer of the front face of the die (side with the longest chamfer) squarely on the work.

(e) Rotate the die slowly, but firmly, until the threads take hold. After cutting several threads, stop to determine if the die is square with the work. Use a try square or suitable tool to check squareness.

(f) Turn the die back a quarter turn after each forward full turn to prevent teeth from breaking off and for ease of threading.

Note. - When threading hard materials, use cutting oil liberally.

(g) Back the die off the newly cut thread carefully and check the cut threads with the proper screw pitch gage.

(2) Adjustment for pitch diameter. The diestock (fig 33) for holding round split open adjusting dies (fig 32) has three screws. A fine pitch screw in this diestock enters the split in the die and forces the sides apart and the other two screws are on the opposite side for compressing. A single screw diestock (fig 33) is used to hold dies of the round split screw adjusting type (fig 32), that are provided with an adjusting screw which forces the sides apart or allows them to spring together, although this type die will fit in a three-screw diestock as well. Two-piece rectangular dies (fig 32) are adjusted by setscrews at either end of the diestock or of the slot in the collet (fig 33 and 34) in which they are placed.

(3) Threading pipe. The procedure for threading pipe is as described below.

(a) Lock the pipe securely in a pipe vise (fig 40).

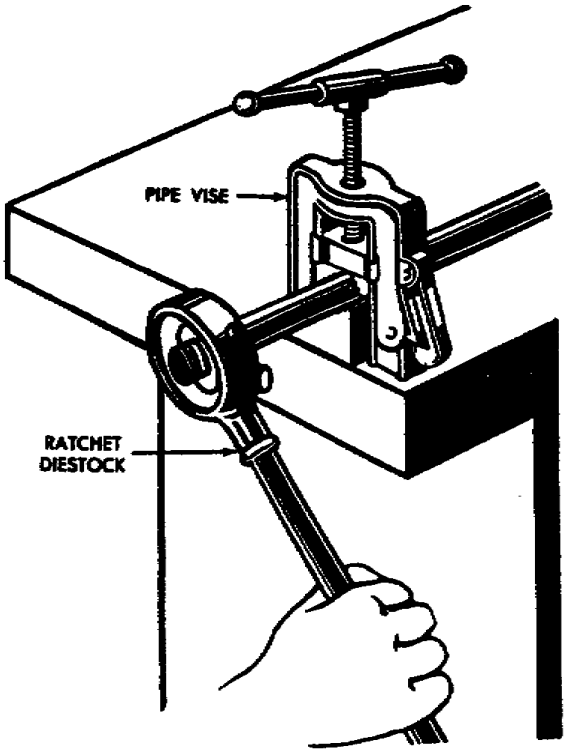


Figure 40. Threading pipe.

(b) Inspect the dies to see that they are sharp and free from nicks.

(c) Assemble two-piece rectangular pipe die (fig 32) on adjustable die guide and ratchet diestock (fig 34).

(d) Set the die to the desired size.

(e) Apply cutting oil to cutting edges of die and to the pipe to prevent overheating of dies and marring of the cut threads.

(f) Place diestock on the pipe and push lightly with the heel of your hand until the die is up against the end of the pipe. Adjust guide to admit pipe by loosening thumbscrew (fig 34), rotate cam plate until guide fits pipe, and tighten thumbscrew after adjustment.

(g) Rotate the diestock clockwise a few short strokes to start the cut. Lock ratchet and pump handle up and down several strokes (fig 40).

(h) Reoil die.

(1) Reverse ratchet and stroke frequently to free die of chips.

(j) Thread pipe until threaded end of pipe projects 1/4 to 1/2 inch from diestock.

(k) After threading, set ratchet for reverse operation and back off die.

(1) Check for proper length of threaded pipe. For determining the length of threaded pipe for standard fittings and couplings for various size pipe, refer to figure 41.

Size of pipe (in.)	O.D. Inches	Number of threads per inch	Total length of threads (in.)
¼	0.540	18	5/16
⅜	0.675	18	5/16
½	0.840	14	13/16
¾	1.050	14	13/16
1	1.315	11½	1
1¼	1.660	11½	1
1½	1.900	11½	1
2	2.375	11½	1 1/16
2½	2.875	8	1 5/16
3	3.500	8	1 5/8
4	4.500	8	1¾
5	5.563	8	1 13/16
6	6.625	8	1 15/16

Figure 41. Pipe thread data for standard pipe.

11. THREAD CHASERS.

a. Purpose of thread chasers. Thread chasers are used to rethread damaged external or internal threads.

b. Types of thread chasers. Thread chasers (fig 42) are threading tools that have several teeth. These tools are available to chase threaded parts having standard threads. The internal thread chaser has its cutting teeth located on a side face. The external thread chaser has its cutting teeth on the end of the shaft. The handle end of the tool shaft tapers to a point.

c. Use of thread chasers. Select the proper thread chaser for the job. You must know the number of threads per inch on the work. Simply use a rule to measure off a distance and count the threads in the measured distance. If screw pitch gages are available use them to determine the number of threads per inch. Secure the work securely in a vise or hold it in one hand. Hold the chaser in the other hand and run it around the threaded section. Hold chaser firmly so that the cutting teeth are parallel to the threads in the work. The cutting action will follow the previously cut threads and restore the damaged portion.

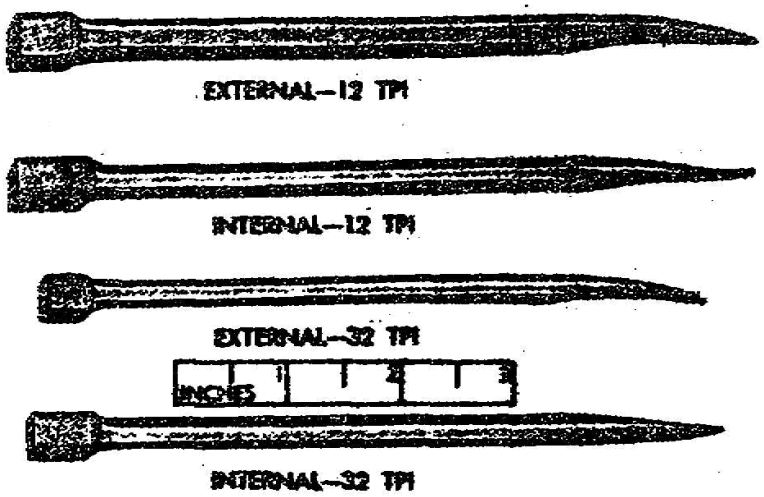


Figure 42. Thread chasers.

12. JOINING.

a. Fittings.

(1) Principles. Fittings are generally screwed to one end of the pipe while it is still in the vise after cutting, reaming, and threading. The assembled pipe and fittings are then screwed into the proper place on the equipment. The steps below describe how to make up leakproof joints.

(2) Procedure.

(a) Inspect the female thread on the fitting and, if necessary, clean it with a stiff brush.

(b) Repeat the same procedure for the male thread on the pipe.

(c) Coat the male thread evenly with pipe joint compound. Do not put any compound on the female thread.

(d) Screw the fitting on the pipe, making sure that the fitting turns easily for the length of about three threads.

(e) Using a wrench, tighten the fitting on the pipe until the joint is tight. Figure 43 shows three common wrenches which were covered in lesson 1. The stillson wrench {1, fig 43) is used for ordinary work; the strap wrench (2, fig 29) for polished or plated pipe; and the chain wrench or chain tongs (3, fig 43) for pipe 3 inches or larger. Use the right size wrench for the size of pipe and never use a length of pipe as an extension handle for added leverage. Use a second wrench to keep an already installed pipe or fitting from turning. If a pipe has been threaded to the correct length, two or three threads will show beyond the face of the fitting.

(f) Wipe off excess joint compound and paint the exposed threads with an acid-resistant paint.

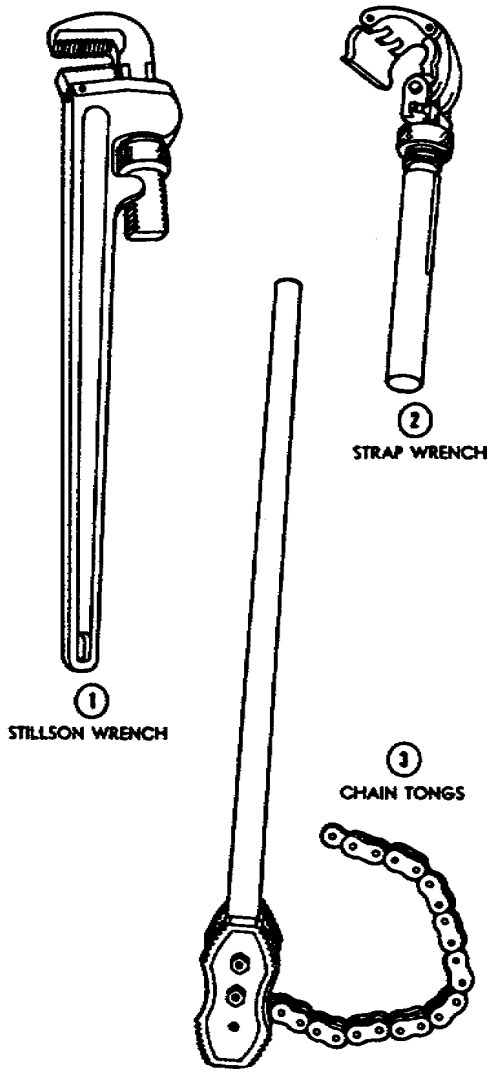


Figure 43. Pipe wrenches.

b. Soldering.

(1) Considerations. To make a leakproof joint all tarnish must be completely removed from the end of the tubing and the inside of the fitting so that the solder will tin all surfaces evenly. The next important step is to get a temperature which allows the solder to flow evenly into and completely fill the joint. If the temperature is too high, the solder will spurt out of the fitting.

(2) Procedure.

(a) Inspect the end of the tubing to make sure it is round and free of burs.

(b) Clean and brighten the end of the tubing and inside of the fitting with fine steel wool or emery cloth until both are highly polished. Do not use a file as it will scratch the surface.

(c) Apply a thin coat of noncorroding flux to the polished portion of both the tubing and the fitting.

(d) Push the tubing into the fitting and turn it a few times to spread the flux evenly. Remove excess flux from the outside of the fitting.

(e) Heat the connection evenly with a torch; apply the flame directly to the fitting. On large size tubing (over 1-1/4 inches) use two torches, when possible, one on each side, to obtain even heating.

(f) When the flux bubbles out (about 45 seconds with an acetylene torch and about 1 minute with a liquified-petroleum torch), remove the torch and apply the end of a length of wire solder to the edge of the joint. If the fitting and tubing are hot enough, the solder will melt and be drawn into the joint. When a line of solder shows completely around the joint, the connection is filled with solder.

(g) Take the following precautions when making soldered connections:

1. When the joint is close to wood or other combustible material, place an asbestos or metal sheet between the fitting and the combustible material.

2. Make sure that the tubing and fitting are kept motionless while the solder is cooling. Any movement may-result in a faulty joint. Solder will harden in a minute or less if the joint has not been overheated.

3. When tubing is joined to a fitting that is already soldered to other tubing (as in joining to the side takeoff of a tee already joined to a through line), wrap a wet rag around the finished joints. This prevents the solder in these joints from melting.

(h) Additional information on soldering is available in lesson 3.

13. REPAIRS.

a. Pipes. Small leaks in a system may require temporary or emergency repairs if materials needed to repair them permanently are not readily available. A permanent repair should be made as soon as possible to replace the weak or defective part with units the same size and quality as the original installation. Before making any repairs, relieve the pressure from the system. Pipes can be temporarily repaired in a number of ways.

(1) Rubber hose or plastic tubing. Cut the pipe on either side of the leak with a hacksaw or pipe cutter. Remove the damaged pipe section and replace it with a length of rubber hose or plastic tubing by slipping the ends over the pipe and fastening them with hose clamps. The inside diameter of the hose must fit the outside diameter of the pipe.

(2) Sheet rubber. Wrap the leaking area with sheet rubber. Place two sheet metal clamps, one on each side of the pipe, and fasten the clamps with nuts and bolts.

(3) Electrician's friction tape. Wrap several layers of electrician's friction tape around the hole or crack extending it about 2 inches above and below the leak.

(4) Wood plugs. Small holes are sometimes filled with wood plugs. The plug is driven into the hole after it is drilled or reamed. Hardwood is the best. The plug will swell because it absorbs water and this prevents it from being blown out by pressure.

b. Valves. Because of the large number of valves used in systems, a mechanic must know how to maintain and repair them. All valves should be checked regularly for leaks. Leaks may be caused by leaking washers or leaking bonnets.

(1) Globe valves.

(a) Washers. To repair a globe or compression type valve (fig 44) with a rubber or fiber disk, first shut off the water at the main and drain the line. Using a suitable wrench, such as a crescent-type adjustable wrench or a monkey wrench, remove the valve bonnet and stem and inspect the disk for wear. If the disk shows wear, unscrew the disk retaining nut and replace the disk with another of the correct size. Inspect the seat of the valve for pitting. If pitting is severe, replace the whole valve, but when the pitting is minor, the valve will often function perfectly with a new disk. Several manufacturers make valves with replaceable brass valve seats. To repair such a valve, follow the manufacturer's recommendations.

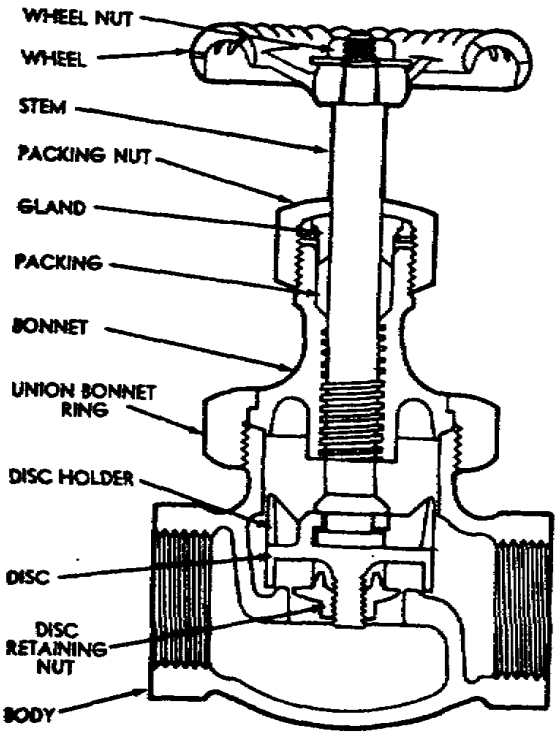


Figure 44. Details of globe valve.

(b) Bonnets. Before replacing the stem and bonnet, slide the bonnet up toward the handle on the stem to expose the bonnet packing. If the valve is leaking through the bonnet or if the packing appears worn, wrap a few strands of lamp wicking dipped in pipe joint compound around the stem and then slide the bonnet down over the packing. Screw the bonnet and stem assembly back into the valve body.

(2) Gate valves. Maintenance of the gate valve is similar to that of the globe valve except that the only part of the valve which needs attention is the bonnet packing. This is replaced in the same way as on the globe valve.

14. CARE OF TOOLS.

a. Care of cutters and flaring tools.

(1) Cutter wheels. The cutting wheel on a pipe or tube cutter must be removed and sharpened when it becomes dulled, nicked, or otherwise damaged. Remove the wheel by tapping out the pin in the center of the wheel or by backing out the attaching screw on some types. Secure the wheel in a suitable jig and carefully grind the cutting edge on a grinder abrasive wheel or grindstone. Preserve the temper by frequently dipping the cutter wheel in water during grinding. Any wire edge can be removed on an oilstone.

(2) Storage. Clean and wipe cutters and flaring tools with a thin film of oil before putting away. Carefully store tools to prevent cutting wheels from becoming damaged. For long periods of storage, coat all parts of cutters and flaring tools with a rust-preventive compound. Wrap cutter wheels in cotton or a small piece of rag saturated with light machine oil to prevent damage and store in a dry place.

b. Care of reamers.

(1) Do not expect a reamer to remove more than 0.002 to 0.003 inch of metal. If the hole is too small, enlarge it with a drill before reaming it.

(2) Keep reamers absolutely clean to do accurate work.

(3) Handle all reamers carefully; if they are dropped or thrown against other tools, their sharp edges will be nicked and dulled.

(4) Wrap reamers in oiled cloth when not in use and store each reamer separately to protect its cutting edges.

(5) If the proper pressure is applied in use and the reamer chatters, replace it. Chattering indicates a poorly or incorrectly sharpened tool If the reamer edges are only slightly dulled, honing the edges on an oilstone may restore the sharpness. The blades on an adjustable reamer may be replaced. Resharpening reamers is a factory or depot operation. Special jigs and equipment are required to sharpen reamer edges correctly. To insure accurate work, always replace a reamer that requires sharpening.

(6) For long periods of storage, clean reamers thoroughly and coat with a rust-preventive compound. Wrap each reamer separately in oiled cloth and store in a dry, safe place.

c. Care of taps and dies.

(1) Maintenance. Do not attempt to sharpen taps or dies. Sharpening of taps and dies involves several highly precision cutting processes where the thread characteristics, chamfer angle, and, in some cases, the book angle and spiral point are involved. These cutting procedures must be accomplished by experienced personnel in order to maintain the accuracy and cutting effectiveness of taps and dies.

(2) Cleaning. Keep taps and dies clean and well oiled when not in use. Store them so that they do not contact each other or other tools.

(3) Storage. For long periods of storage, coat taps and dies with a rust-preventive compound; place in individual or standard threading set boxes in a dry place.

d. Care of thread chasers. Never attempt to sharpen thread chasers yourself as this is a highly specialized cutting process and involves precision work on hard tool steel of a shape altogether not suited for simple stroking on an oilstone. Store chasers carefully when not in use. Coat with a light film of oil and case individually so that the cutting edges do not touch other metal. For long periods of storage, coat chasers with a rust-preventive compound and store in a dry place.

15. SAFETY. Because of high pressures and temperatures found in some types of equipment extreme caution must be taken. A few safety rules are:

a. Shut off all steam lines and remove pressure before attempting maintenance.

b. Allow lines to cool before working on them.

c. Insulate exposed steam lines within easy reach of personnel to prevent burns.

d. Do not permit smoking in the area when installing or repairing fuel lines.

e. Test all lines before use.

EXERCISE

22. What would be the advisable bending radii for a 1/2-inch iron pipe?

a. 1-3/4 inches
b. 3-1/4 inches
c. 2-1/2 inches

23. What is used with the die block to make a double flare in the ends of tubing?

a. Flanging tool
b. Double cutter
c. Yoke and adapters

24. How often is the pipe cutter handle rotated when cutting pipe?

a. Quarter turn clockwise for each complete revolution
b. Quarter turn counterclockwise for each complete revolution
c. Just keep tight enough to prevent cutters from slipping

25. What is used to prevent solid reamers from chattering?

a. Evenly spaced lands
b. Spiral flutes
c. Irregularly spaced lands

26. What caution should be taken when using a reamer?

a. Do not turn the wrench clockwise
b. Use solid straight hole reamer for work not requiring accuracy
c. Do not turn the wrench counterclockwise

27. The most common taps issued are the

a. boiler and bottom.
b. taper, plug, bottom, and pipe.
c. mud and taper.

28. The type of die that will cut American Standard pipe thread ONLY is the

a. square pipe die.
b. rethreading die.
c. adjustable die.

29. Which statement is TRUE in respect to joining pipes and fittings?

a. Coat only female threading with pipe joint compound
b. Coat only male threading with pipe joint compound
c. Coat both male and female threading with pipe joint compound

30. What corrective action is taken when the proper pressure is used on a reamer and it chatters?

a. Replace
b. Sharpen with a grindstone
c. Sharpen with a file

16. SUMMARY. In this lesson we have covered the basic procedures for pipefitting to include measuring, fittings, cutting, reaming, threading, and use and care of pipefitting tools. Your ability to supervise repairmen in the performance of these procedures could very easily be the difference between having a piece of equipment operational rather than deadlined.

LESSON ASSIGNMENT

Ordnance Subcourse No 017.....	Supporting Services
Lesson 3.....	Introduction to Welding, Cutting, Brazing, and Soldering
Lesson Objective.....	After studying this lesson you will be able to: 1. Describe the procedures for setting up oxyacetylene welding equipment to include flame adjustments. 2. Explain oxyacetylene cutting operations of mild steel. 3. Describe oxyacetylene brazing operations. 4. Describe soldering operations to include safety procedures.
Text.....	Attached Memorandum
Materials Required.....	Response list and answer sheet
Suggestions.....	Study illustrations as the text is read. If possible, visit a maintenance shop where welding, cutting, brazing, and soldering equipment is available and observe the actual operations.

ATTACHED MEMORANDUM

SECTION I. GENERAL

1. INTRODUCTION.

a. The use of a welding torch in metalworking is by no means a new thing. A crude form of welding torch was used by the Ancient Egyptians, Greeks, and Romans to work on precious metals. The flame came from alcohol and other fluids. Although acetylene was discovered as early as 1836, it was not widely used, except in laboratories, until 1892 when a method of producing calcium carbide was discovered. The year 1903 marks the beginning of the oxyacetylene process for general welding and cutting.

b. Metalworking with its many related activities is an important function in a maintenance unit. The mission of these various units could not be fully and efficiently accomplished without personnel qualified in metalworking. The techniques and procedures presented in this lesson are by no means the answer to all problems encountered in the field; however, the procedures covered have been proved by long usage.

SECTION II. SAFETY

2. GENERAL. Great care should be taken in handling any type of welding equipment to prevent personnel injury from fire, explosions, or harmful agents. Both general and specific safety precautions listed below must be strictly observed by workers who weld or cut metals.

a. Do not permit unauthorized persons to use welding or cutting equipment.

b. Do not weld in building with wooden floors, unless the floors are protected from hot metal by means of asbestos fabrics, sand, or other fireproof material. Be sure that hot sparks or hot metal will not fall on the legs and feet of the operator or on any welding equipment components.

c. Remove all flammable material such as cotton, oil, gasoline, etc, from the vicinity of welding.

d. Before welding or cutting warn those in close proximity who are not protect-ed by proper clothing or goggles.

e. Remove assembled parts that may become warped or otherwise damaged by the welding process.

f. Do not leave hot, rejected electrode studs, steel scrap, or tools on the floor about the welding equipment. These may cause accidents.

g. Keep a suitable fire extinguisher conveniently located at all times.

h. Mark all hot metal after welding operations are completed.

3. PROTECTION OF THE EYES AND SKIN.

a. General. Protective clothing and equipment must be worn during welding operations. During all oxyacetylene welding and cutting processes, operators will use safety goggles to protect the eyes from heat, glare, and flying fragments of hot metals. During all electric welding processes, operators will use safety goggles and a hand shield or helmet equipped with a suitable filter glass (depending upon the size of the welding rods or the magnitude of the welding or cutting current) to protect against the intense ultraviolet and infrared rays. When others are in the vicinity of electric welding processes, the area must be screened so that the arc cannot be seen either by direct vision or by reflection from glass, metal, or other materials which reflect these rays.

b. Protective clothing.

(1) Woolen clothing should be worn instead of cotton, because the wool is not easily burned or damaged by weld metal spatter,

(2) Aprons or jackets made of asbestos cloth or leather should be worn to provide protection against spatter of molten metal. This is especially important when welding in the vertical or overhead position.

(3) The welder should wear high upper shoes and his pants should be without cuffs so that the molten metal will not be caught in them.

(4) Flameproof gauntlet gloves, preferably of leather, should be worn to protect the hands and arms from the rays of the arc, molten metal spatter, sparks, and hot metal. Leather gloves should be of sufficient thickness so that they will not shrivel in heat, burn through, or wear out quickly. Do not allow oil or grease to come in contact with the gloves because this will reduce their flame resistance and cause them to be readily ignited or charred.

c. Protective equipment.

(1) To safeguard the eyes and face from harmful light rays and particles of hot metal, goggles, spectacles, or helmets with colored lenses should be worn when welding or cutting by any process. The color of the lenses, usually blue or brown, is an added protection against the intensity of white light or glare. Colored lenses make it possible to clearly see the metal and weld.

(2) Do not weld with cracked or defective shields because penetrating rays from the arc may cause serious burns. Be sure that the colored glass plates are the proper shade for arc welding. Protect the colored glass plate from spatter by using a cover glass. Replace these cover glasses when damaged or spotted by molten spatter.

Note. - This colored glass must be manufactured in accordance with specifications detailed in the "National Safety Code for the Protection of the Hands and Eyes of Industrial Workers, " issued by National Bureau of Standards, Washington, D.C.

(3) Two basic types of helmets are commonly used to protect eyes and all parts of the head which might be contacted with injurious rays. One type is worn on the welder's head and when not in use can be raised out of the way on a hinged strap. The other is a hand shield type which is held over the face with one hand by means of a handle. These helmets are made of vulcanized fiber and are dull black in color to minimize light reflection.

4. FIRE HAZARDS.

a. During welding and cutting operations sparks and molten spatter are formed and sometimes fly appreciable distances. For this reason, welding or cutting should not be done near flammable materials unless every precaution is taken to prevent ignition.

b. Whenever possible, flammable materials attached to or near equipment requiring welding, brazing, or cutting should be removed. If removal is not practical a suitable shield of asbestos or other heat-resistant material should be used to protect the flammable material. Fire extinguishing equipment for the type of fire that may be encountered is to be present.

c. When welding or cutting parts of vehicles, the oilpan, gasoline tank, etc, should be considered fire hazards and effectively shielded from sparks, slag, and molten metal.

5. VENTILATION.

a. When using welding equipment in a closed area make certain to provide proper ventilation and be sure that no traces of gasoline, acetylene, or other explosive vapors are present in the area. Station an assistant outside the danger zone. This assistant should be instructed to look out for fires and take other necessary action in case of any emergency.

b. The fumes of burning paint or those generated during brazing, welding, or cutting of brass, lead, zinc, and galvanized or cadmium plated parts are filled with poisonous particles of oxides, lead, or zinc.

WARNING: Under the action of an electric arc, nitrogen and oxygen from the air are converted into poisonous compounds. If welding is conducted in a confined and insufficiently ventilated space these compounds may become highly concentrated and, if inhaled in any appreciable quantity, they may cause serious disability or death.

c. Because welding operations usually generate harmful gases, fumes, and dust, adequate ventilation is essential. Local exhaust systems should be provided to remove such substances. Where the nature of the work requires further protection, special respiratory equipment should be furnished the operators. Many unknown toxic hazards can be encountered, particularly in experimental welding of new types of materials. Required ventilation standards and standard operating procedures should be cleared through the safety inspector before starting such a new operation.

6. SAFETY IN OXYGEN AND ACETYLENE WELDING. In addition to the information listed in paragraphs 2 through 5, the following precautions must be observed when involved in oxygen and acetylene operations.

a. General.

(1) Do not experiment with torches or regulators in any way. Do not use oxygen regulators with acetylene cylinders.

(2) Always use the proper tip of nozzle, and always operate it at the proper pressure for the particular work involved. This information should be taken from work-sheets or tables supplied with the equipment.

(3) When not in use make certain that the torch is not burning and that the valves are tightly closed. Do not hang the torch with its hose on the regulator or cylinder valves.

(4) Do not light a torch with a match, from hot metal, or in a confined space. The explosive mixture of acetylene and oxygen might cause personal injury or property damage when ignited. Use friction lighters, stationary pilot flames, or some other suitable source of ignition.

(5) When working in confined spaces provide adequate ventilation for the dissipation of explosive gases that may be generated.

(6) Keep a clear space between the cylinder and the work so that the cylinder valves can be reached easily and quickly.

(7) Use cylinders in the order received. Store full and empty cylinders separately and mark the latter MT.

(8) Compressed gas cylinders owned by commercial companies should not be painted regulation Army olive drab while in the hands of the troops.

(9) Never use cylinders for rollers, supports, or any purpose other than that for which they are intended.

b. Acetylene cylinders.

(1) Always refer to acetylene by its full name and not by the word "gas" alone. Acetylene is very different from city or furnace gas.

(2) Acetylene cylinders should be handled with care to avoid damage to the valves or the safety fuse plug. The cylinders should be stored upright in a well ventilated, well protected, dry place at a safe distance from highly combustible materials such as oil or paint. Do not store the cylinders near radiators, furnaces, or in any above normal temperature area. The heat will increase the pressure which may cause the safety fuse in the cylinder to blow out. Storage areas should be located away from elevators, gangways, or other places where there is danger of their being knocked over or damaged by falling objects.

(3) A suitable truck, chain, or strap should be used to prevent cylinders from falling or being knocked over while in use. Cylinders should be kept at a safe distance from the welding operation so that there will be little possibility of sparks, hot slag, or flames reaching them. They should be kept away from radiators, piping systems, layout tables, etc, which may be used for grounding electrical circuits. Nonsparking tools should be used when changing fittings on cylinders of flammable gases.

(4) Never use acetylene from cylinders without reducing the pressure with a suitable pressure reducing regulator. Never use acetylene at pressures in excess of 15 PSI.

(5) Before attaching the pressure regulators open each acetylene cylinder valve for an instant to blow dirt out of the nozzles. Wipe off the connection seat with a clean cloth. Do not stand in front of valves when opening them.

(6) Outlet valves which have become clogged with ice should be thawed with warm water. Do not use scalding water or an open flame.

(7) Be sure the regulator tension screw is released before opening the cylinder valve. Always open the valve slowly to avoid strain on the regulator gage which records the cylinder pressure. Do not open the valves more than one and one-half turns. Usually one-half turn is sufficient. Always use the special T-wrench provided for the acetylene cylinder valve. Leave this wrench on the stem of the valve while the cylinder is in use so that the acetylene can be quickly turned off in an emergency.

(8) Acetylene is a highly combustible fuel gas and great care should be taken to keep sparks, flames, and heat away from the cylinders. Never open an acetylene cylinder valve near other welding in cutting work.

(9) Never test for an acetylene leak with an open flame. Test all joints with soapy water. Should a leak occur around the valve stem of the cylinder, close the valve and tighten the packing nut. Cylinders leaking around the safety fuse plug should be taken outdoors, away from all fires and sparks, and the valve opened slightly to permit the contents to escape.

(10) If an acetylene cylinder should catch fire it can usually be extinguished with a wet blanket. A burlap bag wet with calcium chloride solution is effective for such an emergency. If these fail, spray a stream of water on the cylinder to keep it cool.

(11) Never interchange acetylene regulators, hose, or other apparatus with similar equipment intended for oxygen.

(12) Always turn the acetylene cylinder so that the valve outlet will point away from the oxygen cylinder.

(13) When returning empty cylinders, see that the valves are closed to prevent escape of residual acetylene or acetone solvent. Screw on protecting caps.

c. Oxygen cylinders.

(1) Always refer to oxygen by its full name and not-by the word "air" alone.

(2) Keep oxygen away from oil, grease, and other flammable materials. Do not handle oxygen cylinders, valves, regulators, hose, or apparatus with oily hands. Do not permit a jet of oxygen to strike greasy clothes, any oily surface, or to enter a fuel oil storage container.

WARNING: Oil or grease in the presence of oxygen will ignite violently. Especially in enclosed pressurized areas.

(3) Do not store oxygen cylinders together with cylinders containing acetylene or other fuel gases. They should be grouped separately with a fire resisting wall between the acetylene and oxygen cylinders.

(4) When oxygen cylinders are in use or being moved, care must be taken to avoid dropping, knocking over, or striking the cylinders with heavy objects. Do not handle oxygen cylinders roughly.

(5) All oxygen cylinders with leaky valves or safety fuse plugs should be set aside and marked for the attention of the supplier. Do not tamper with or attempt to repair oxygen cylinder valves. Do not use a hammer or wrench to open the valves.

WARNING: Do not substitute oxygen for compressed air in pneumatic tools. Do not use it to blow out pipelines, test radiators, purge tanks or containers, or to dust clothing or work.

(6) Open the oxygen cylinder valve slowly to prevent damage to the regulator high-pressure gage mechanism. Be sure that the regulator tension screw is released before opening the valve. When not in use, the cylinder valves should be closed and the protecting caps screwed on to prevent damage to the valves.

(7) When the oxygen cylinder is in use open the valves to the full limit to prevent leakage around the valve stem.

(8) Always use regulators on oxygen cylinders to reduce the cylinder pressure to a low working pressure. Otherwise the high pressure will burst the hose.

(9) Never interchange oxygen regulators, hose, or other apparatus with similar equipment intended for other gases.

d. Hose.

(1) Do not allow the hose to come in contact with oil or grease. These will penetrate and deteriorate the rubber and constitute a hazard with oxygen.

(2) Always protect the hose from being walked on or run over. Avoid kinks and tangles. Do not leave the hose where anybody can trip over it. This could result in personal injury, damaged connections, or cylinders being knocked over. Do not work with the hose over your shoulder, around your legs, or tied to your waist.

(3) Protect the hose from hot slag, flying sparks, and open flames.

(4) Never force hose connections that do not fit. Do not use white lead, oil, grease, or other pipe fitting compounds for connections on hose torch, or other equipment. Never crimp hose to shut off gases.

(5) Examine all hose periodically for leaks by immersing hose in water while under pressure. Do not use matches to check for leaks in the acetylene hose,. Repair leaks by cutting hose and inserting a splice. Do not use tape for mending. Replace hose if necessary.

(6) Make sure that the hose is securely attached to torches and regulators before using.

(7) Do not use new or stored hose lengths without first blowing them out with compressed air to eliminate talc or accumulated foreign matter which might otherwise enter and clog the torch parts.

(8) Do not tape oxygen and acetylene hoses together.

7. SAFETY PRECAUTIONS FOR WELDING AND CUTTING CONTAINERS THAT HAVE HELD COMBUSTIBLES.

a. Explosion hazards.

(1) In heating, welding, and cutting of containers which are not free of combustible solids, liquids, vapors, dusts, and gases, severe explosions and fires may result. Containers of this kind can be made safe by following one of the methods described below.

WARNING: Do not presume that a container is clean and safe until proven so by proper tests. Do not weld in places where dust or combustible particles are suspended in air or where explosive vapors are present.

(2) Flammable and explosive substances may be present in a container because it previously held one of the following substances.

(a) Gasoline, light oil, or other volatile liquid that releases potentially hazardous vapors at atmospheric pressure.

(b) An acid that reacts with metals to produce hydrogen.

(c) A nonvolatile oil or a solid that will not release hazardous vapors at ordinary temperatures, but will release such vapors when exposed to heat.

(d) A combustible solid; i.e., finely divided particles which may be present in the form of an explosive dust cloud.

b. Preparing the container for cleaning.

(1) In cleaning do not use chlorinated hydrocarbons, such as trichloroethylene or carbon tetrachloride. The materials may be decomposed by the heat or radiation from welding or cutting to form phosgene.

(2) Disconnect or remove from the vicinity of the container all sources of ignition before cleaning is started.

(3) Personnel cleaning the container must be protected against harmful exposure.

(4) If practical, move the container into the open. When indoors make sure the room is well ventilated.

(5) Empty and drain the container thoroughly, including all internal piping, traps, and standpipes. Removal of scale and sediment may be facilitated by scraping, hammering with a nonferrous mallet, or by using a nonferrous chain as a scrubber. Do not use any tool which may spark and cause flammable vapors to ignite. Dispose of the residue before starting to weld or cut.

(6) Identify material for which the container was used; determine its flammability and toxicity characteristics. If the substance previously held by the container is not known. assume that the substance is flammable, toxic, and insoluble in water.

(7) Cleaning a container that has held combustibles is necessary in all cases before any welding or cutting is done. This cleaning may be supplemented by filling the container with water or by using an inert gas both before and during such work.

(8) Treat each compartment in a container having two or more compartments in the same manner, regardless of which compartment is to be welded or cut.

c. Methods of precleaning containers having held flammable liquids.

(1) It is very important for the safety of personnel to completely clean all tanks and containers which have held volatile or flammable liquids of all dangerous fumes. Safety precautions cannot be overemphasized of the dangers involved when these items are not thoroughly purged prior to the application of heat-especially an open flame.

(2) Accepted methods of cleaning. The various methods of cleaning these containers follow. However, the steam cleaning and automotive exhaust methods are considered, by military personnel, to be the safest and easiest methods of purging these containers.

d. Automotive exhaust method of cleaning.

(1) Completely drain the container of all fluid.

(2) Fill the container at least 25 percent full of a solution of hot soda or detergent (1 lb-per gallon of water) and rinse it sufficiently to insure that the inside surface is thoroughly flushed.

(3) Drain the solution and again rinse the container with clean water.

(4) Open all inlets and outlets of the container.

(5) Using a flexible tube, hose, or other method of directing the exhaust from a motor vehicle or stationary engine, direct a stream of exhaust fumes into the container making sure that there are sufficient openings to allow the fumes to flow through the container.

(6) Allow the fumes to circulate through the container for 30 minutes or until the container is so hot it cannot be handled.

(7) Disconnect the tube from the container and using compressed air (min 50 PSI) blow out all fumes.

e. Steam method of cleaning.

(1) Fill the container at least 25 percent full with hot soda detergents or soda ash solution (1 lb per gallon of water) and agitate it sufficiently to insure that the inside surfaces are thoroughly flushed.

Note. - Do not use soda ash solution on aluminum.

(2) Drain the container thoroughly.

(3) Close all openings in the container with the exception of the drain and filling connection or vent. Use damp asbestos, damp wood flour, or similar material for sealing cracks or other damaged sections.

(4) Use steam under low pressure and a hose of at least 3/4-inch diameter. In this method use low-pressure steam. Control the steam pressure by a valve ahead of the hose. If a metal nozzle is used at the outlet end it should be made of nonsparking material and should be electrically connected to the container; the container, in turn, should be grounded to prevent an accumulation of static electricity.

(5) The procedure for the steam method of cleaning is as follows:

(a) Blow steam into the container, preferably through the drain, for a period of time to be governed by the condition or nature of the flammable substance previously held by the container. When a container has only one opening, position it so the condensate will drain from the same opening into which the steam is inserted. (When steam or hot water is used to clean a container wear suitable clothing, such as boots, hood, etc, to protect against burns.)

(b) Continue steaming until the container is free from odors and the metal parts are hot enough to permit steam vapors to flow freely out of the container vent or similar opening. Do not set a definite time limit for steaming containers as rain, extreme cold, or other weather conditions may condense the steam as fast as it is introduced. It may take several hours to heat the container to such a temperature that steam will flow freely from the outlet of the container.

(c) Thoroughly flush the inside of the container with hot, preferably boiling, water.

(d) Drain the container.

(e) Inspect the inside of the container as described in paragraph ?g(3)(g). If it is not clean, repeat steps (a)(b)(c) and (d) above.

(f) Close the container openings. In 15 minutes test a gas sample as described in paragraph 7g(3)(h).

f. Water method of cleaning.

(1) Water-soluble substances can be removed by repeatedly filling and draining the container with water. Water soluble acids, acetone, and alcohol can be removed in this manner. Diluted acid frequently reacts with metal to produce hydrogen; care must be taken to see that all traces of the acid are removed.

(2) When the original container substance is not readily water soluble, it must be treated by the steam method or hot chemical solution method.

g. Hot chemical solution method of cleaning.

(1) The chemicals generally used in this method are trisodium phosphate (strong washing powder) or a commercial caustic cleaning compound dissolved in water to a concentration of 2 to 4 oz of chemical per gallon of water.

(2) When cleaning by this method guard against injury from steam or the caustic cleaning compound. Use suitable goggles, gloves, and other protective clothing.

(3) The procedure for the hot chemical solution method of cleaning is as follows:

(a) Close all container openings with the exception of the drain and filling connection or vent. Use damp asbestos, damp wood flour, or similar material for sealing cracks or other damaged sections.

(b) Fill the container to overflowing with water, preferably letting water in through the drains. If there is no drain, flush the container by inserting the hose through the filling connection or vent. Lead the hose to the bottom of the container to get agitation from the bottom upward. This causes any remaining liquid, scum, or sludge to be carried upward and out of the container.

(c) Drain the container thoroughly.

(d) Completely dissolve the amount of chemical required in a small amount of hot or boiling water and pour this solution into the container. Then fill the container with water.

(e) Make a steam connection to the container either through the drain connection or by a pipe entering through the filling connection or vent. Lead the steam to the bottom of the container. Admit steam into the chemical solution and maintain the solution at a temperature of 170 to 180°F. At intervals during the steaming add enough water to permit overflowing of any volatile liquid, scum, or sludge that may have collected at the top. Continue steaming until the point is reached when no appreciable amount of volatile liquid, scum, or sludge appears at the top of the container.

(f) Drain the container.

(g) Inspect the inside of the container to see if it is clean. To do this use a mirror to reflect light into the container. If inspection shows that it is not clean, repeat steps (d), (e), and (f) above and inspect. (Use a nonmetal electric lantern or flashlight suitable for inspection of locations where flammable vapors are present.)

(h) Close the container openings. In 15 minutes reopen the container and with a combustible gas indicator test for gas vapor. If the vapor concentration is in excess of 14 percent of the lower limit of flammability, repeat the cleaning procedure.

(4) If steaming facilities for heating the chemical solution are not available, a less effective method is the use of a cold water solution with the amount of cleaning compound increased to about 6 oz per gallon of water. It will help if the solution is agitated by rolling the container or by blowing air through the solution by means of an air line inserted near the bottom of the container.

h. Marking of safe containers. After cleaning and testing that a container is safe for welding and cutting, stencil or tag it. The stencil or tag should include a phrase such as: "Safe for welding and cutting", the signature of the person so certifying, and the date.

i. Filling treatment. It is desirable to fill the container with water during welding or cutting as a supplement to any of the cleaning methods. Where this added precaution is taken, place the container so that it can be kept filled to within a few inches of the point where the work is to be done. Make sure the space above the water level is vented so that the heated air can escape from the container.

8. SUMMARY. There are many other safety precautions to be considered, but safety measures normally associated with oxygen-acetylene operations are the ones covered in the rest of this lesson. Be sure to consult TM 9-237, Operator's Manual, Welding Theory and Operation, before attempting to perform any other type of operation.

EXERCISE

31. Acetylene should never be used at pressures in excess of

a. 10 PSI.
b. 15 PSI.
c. 20 PSI.

32. If an outlet valve on an acetylene cylinder has become clogged with ice, the ice should be thawed by

a. using warm water.
b. using scalding water.
c. using open flame.

33. When using an oxygen cylinder, how far is the valve opened?

a. One full turn
b. Three full turns
c. Full limit

34. Which method of precleaning containers that have held flammable liquids is considered the safest by military personnel?

a. Hot chemical solution
b. Carbon tetrachloride
c. Steam cleaning

35. Which solution should be used on aluminum using the steam cleaning method?

a. Soda detergents
b. Soda ash
c. Chlorinated hydrocarbons

SECTION III. INTRODUCTION TO OXYGEN-ACETYLENE WELDING

9. GENERAL. Welding processes may be broken down into many categories and various methods and materials may be used to accomplish good welding practices. In the oxyacetylene welding process, heat is supplied by the combustion of acetylene and pure oxygen. These gases are mixed in a welding torch and regulated to produce a flame that has the desired welding characteristics. Acetylene and oxygen are the gases most widely used. This lesson will deal only with the oxyacetylene welding process. A chart reflecting many welding processes is shown in figure 1.

10. SCOPE. In principle, oxyacetylene welding is a fundamentally simple, nonpressure process. The phrase "nonpressure process" means that no pressure is required to make a fusion weld; e.g., two pieces of metal brought together with their edges in contact are melted and fused by the heat of the flame with or without the addition of molten metal from a welding rod. The molten edges will flow together until each is completely fused with the other and, after the metal has cooled, there is a single continuous piece. In fusion welding, the base metal and welding rod generally have essentially the same composition. Plain carbon steel, alloy steel, and stainless steel can all be joined by the oxyacetylene fusion welding process.

11. EQUIPMENT. Oxyacetylene welding outfits can be stationary or portable. The portable outfit is most commonly used by the military and will be the system covered by this lesson. The portable oxyacetylene welding outfit consists of an oxygen cylinder and acetylene cylinder with attached valves, regulators, gages, and hoses (fig 2). This equipment may be temporarily secured on the floor or mounted on a two-wheel, all-welded, steel truck equipped with a platform which will support two large size cylinders. The cylinders are secured by chains attached to the truck frame. A metal toolbox, welded to the frame, provides storage space for torch tips, gloves: fluxes, goggles, and necessary wrenches.

a. Oxygen cylinders.

(1) The oxygen cylinder is a seamless, drawn steel bottle with walls about one-half inch in thickness but thicker at the top and bottom.

(2) The cylinder contains approximately 220 cubic feet of oxygen at a pressure of 2,000 PSI at a temperature of 70°F.

(3) Attached equipment consists of an outlet valve, a removable metal cap for the protection of the valve, and a low melting point safety fuse plug and disk.

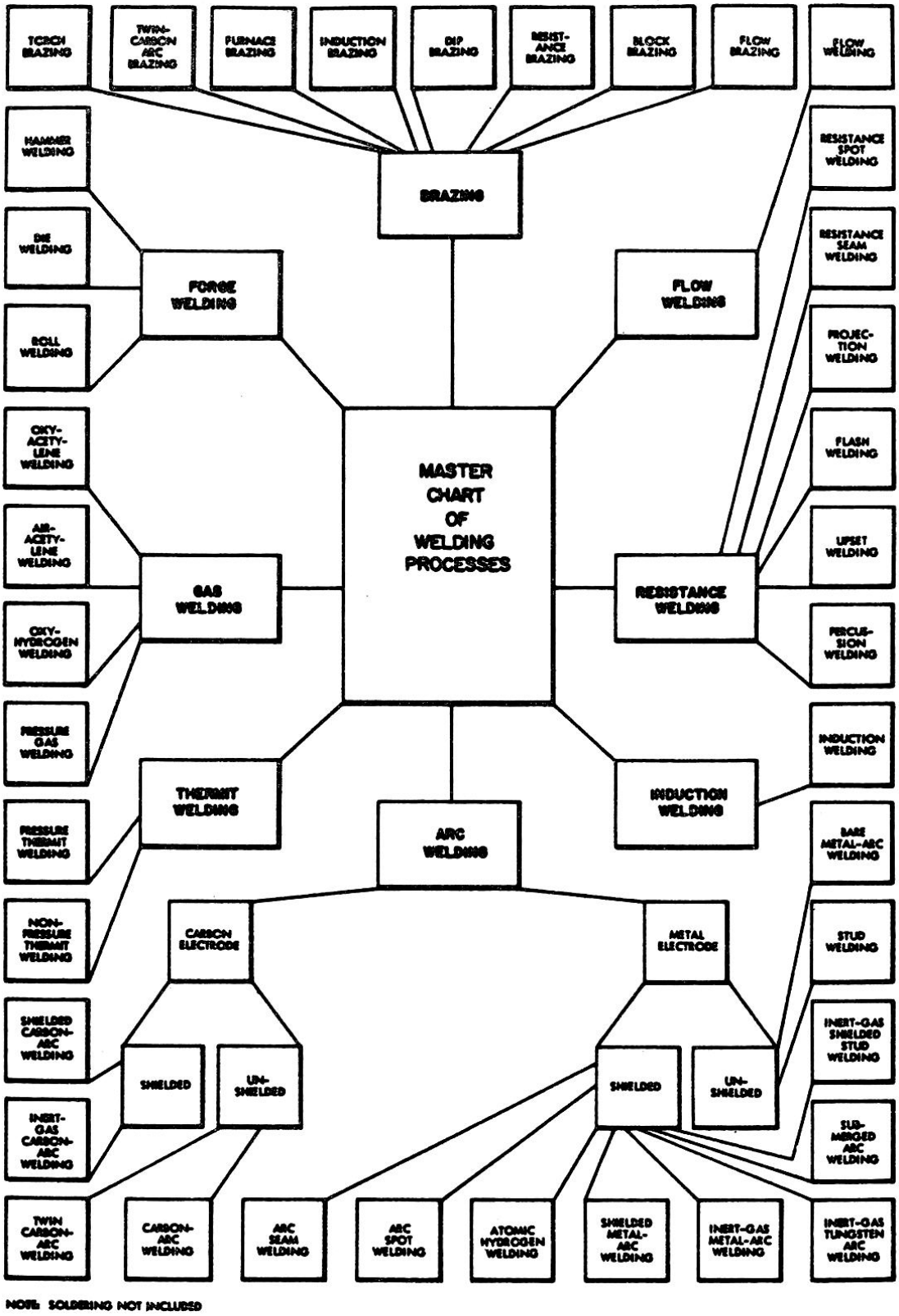


Figure 1. Chart of welding processes.

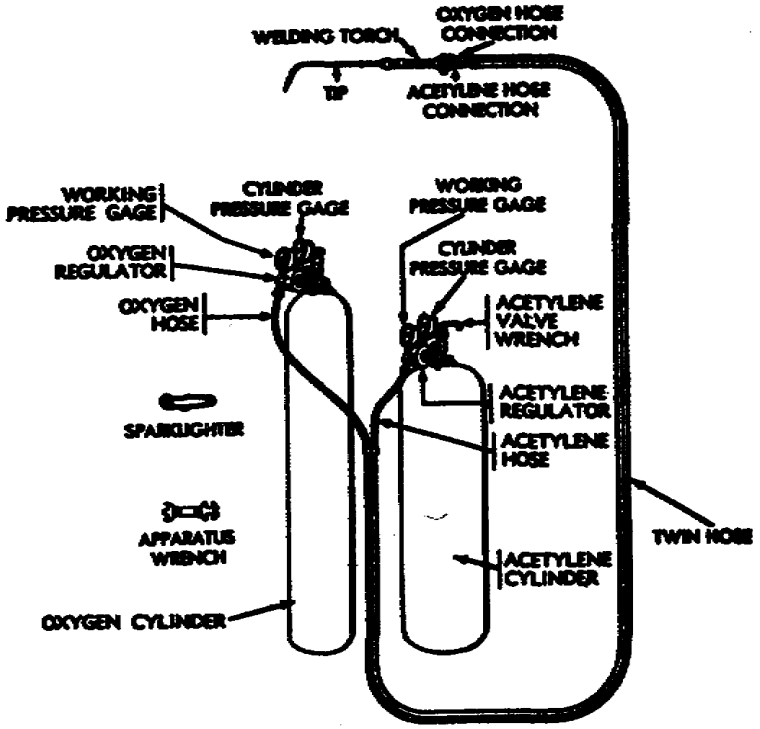


Figure 2,. Portable oxyacetylene welding equipment,

(4) The oxygen cylinder valve is made of tobin bronze which is a soft metal. A steel cap threaded to the top of the cylinder covers this valve and protects it during transportation and storage. The valve has a double seat; the second seat serving to prevent leakage around the valve stem when the valve is fully opened. A bursting disk, held in place by a nut, is supported in the nut by fusible metal that will melt at approximately 212°F to 220°F. This disk will burst, releasing the gas, to prevent development of abnormal pressure in case of fire. Valves have a handwheel on the stem and when in use the valve should be opened as far as it will go. An oxygen cylinder is shown in figure 3.

b. Acetylene cylinders.

(1) Acetylene, when not obtained from an acetylene generator, is provided for welding purposes in steel cylinders with capacities of 10, 40, 125, and 225 cubic feet.

(2) Acetylene stored in a free state under pressure greater than 15 PSI can be made to break down by heat or shock and possibly explode. Under pressure of 29.4 PSI acetylene becomes self-explosive and a slight shock will cause it to explode spontaneously. However, when dissolved in acetone it can be compressed into cylinders at pressures up to 250 PSI. The acetylene cylinder is filled with porous materials such as balsa wood, charcoal, shredded asbestos, corn pith, or portland cement in order to decrease the size of the open spaces in the cylinder. Acetone, a colorless, flammable liquid, is added until about 40 percent of the porous material is filled. The filler acts as a large sponge which absorbs the acetone, which, in turn, absorbs the acetylene. In this process the volume of the acetone increases as it absorbs the acetylene; while acetylene, being a gas, decreases in volume.

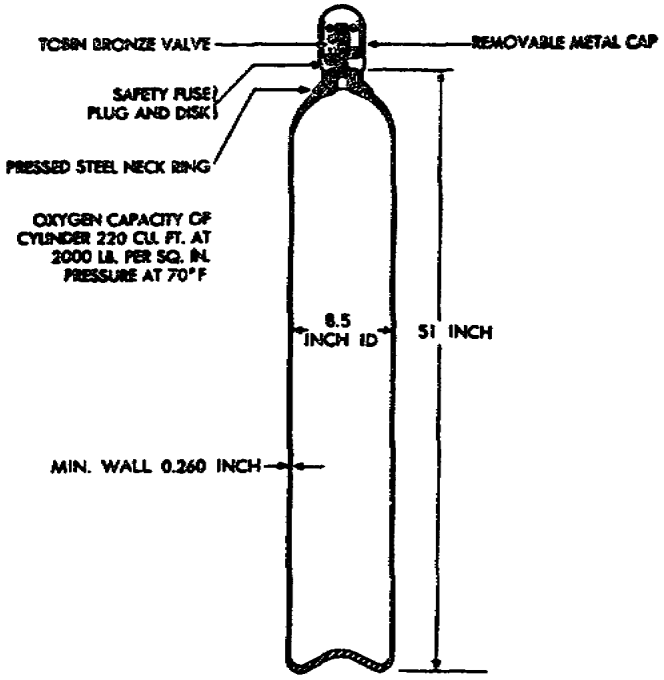

TOBIN BRONZE VALVE
REMOVABLE METAL CAP
SAFETY FUSE PLUG AND DISK
PRESSED STEEL NECK RING
OXYGEN CAPACITY OF CYLINDER 220 CU. FT. AT 2000 LB. PER SQ. IN. PRESSURE AT 70°F
8.5 INCH ID
51 INCH
MIN. WALL 0.260 INCH

Figure 3. Oxygen cylinder construction.

(3) When acetylene is used from a cylinder it should not be drawn off at a continuous rate in volumes greater than 50 cubic feet per hour. This precaution is necessary to prevent the drawing off of acetone and the consequent impairment of weld quality. When more than 50 cubic feet per hour is required, the cylinder should be manifolded.

(4) The acetylene cylinders are equipped with safety plugs having a small hole through the center. This hole is filled with a metal alloy which melts at approximately 212°F. When a cylinder is overheated the plug will melt and permit the acetylene to escape before a dangerous pressure can build up. The plug hole is too small to permit a flame to burn back into the cylinder if the escaping acetylene should become ignited.

(5) The brass acetylene cylinder valves have squared stainless steel valve stems which can be fitted with a cylinder wrench and opened or closed when the cylinder is in use. The outlet of the valve is threaded for connection to an acetylene pressure regulator by means of a union nut. The regulator inlet connection gland fits against the face of the threaded cylinder connection and the union nut draws the two surfaces together. Whenever the threads on the valve connections are damaged to a degree that will prevent proper assembly to the regulator, the cylinder should be marked and set aside for return to the manufacturer.

(6) A protective metal cap screws onto the valve to prevent damage during shipment or storage (fig 4).

CAUTION: All acetylene cylinders should be checked with a soap solution for leakage at the valves and safety fuse plugs, because the acetylene which would accumulate in the storage room or a confined space is a fire and explosion hazard.

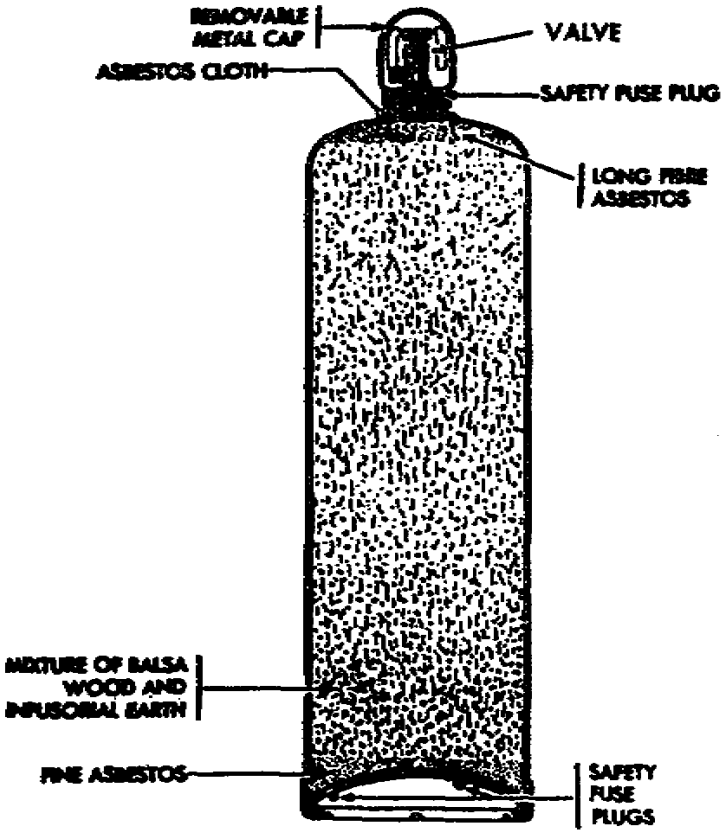


Figure 4. Acetylene cylinder construction.

c. Oxygen and acetylene regulators. The gases compressed in oxygen and acetylene cylinders are at pressures too high for oxyacetylene welding. Regulators are necessary to reduce pressure and control the flow of gases from the cylinders. Most regulators in use are either the single-stage or the two-stage type. Check valves should be installed between the torch hoses and regulator to prevent backflash through the regulator.

(1) Single-stage oxygen regulator. The mechanism of a single-stage regulator (fig 5) has a nozzle through which the high-pressure gas passes, a valve seat to close off the nozzle, and balancing springs. Some types have a relief valve and an inlet filter to exclude dust and dirt. Pressure gages are provided to show the pressure in the cylinder or pipeline and the working pressure. In operation, the working pressure falls as the cylinder pressure falls; for this reason, the working pressure must be adjusted at intervals during welding operations. The oxygen regulator controls and reduces the oxygen pressure from any standard commercial oxygen cylinder containing pressures up to 3,000 PSI. The high-pressure gage, which is on the inlet side of the regulator, is graduated from 0 to 3,000 PSI. The low-pressure gage, which is on the outlet side of the regulator, is graduated from 0 to 500 PSI.

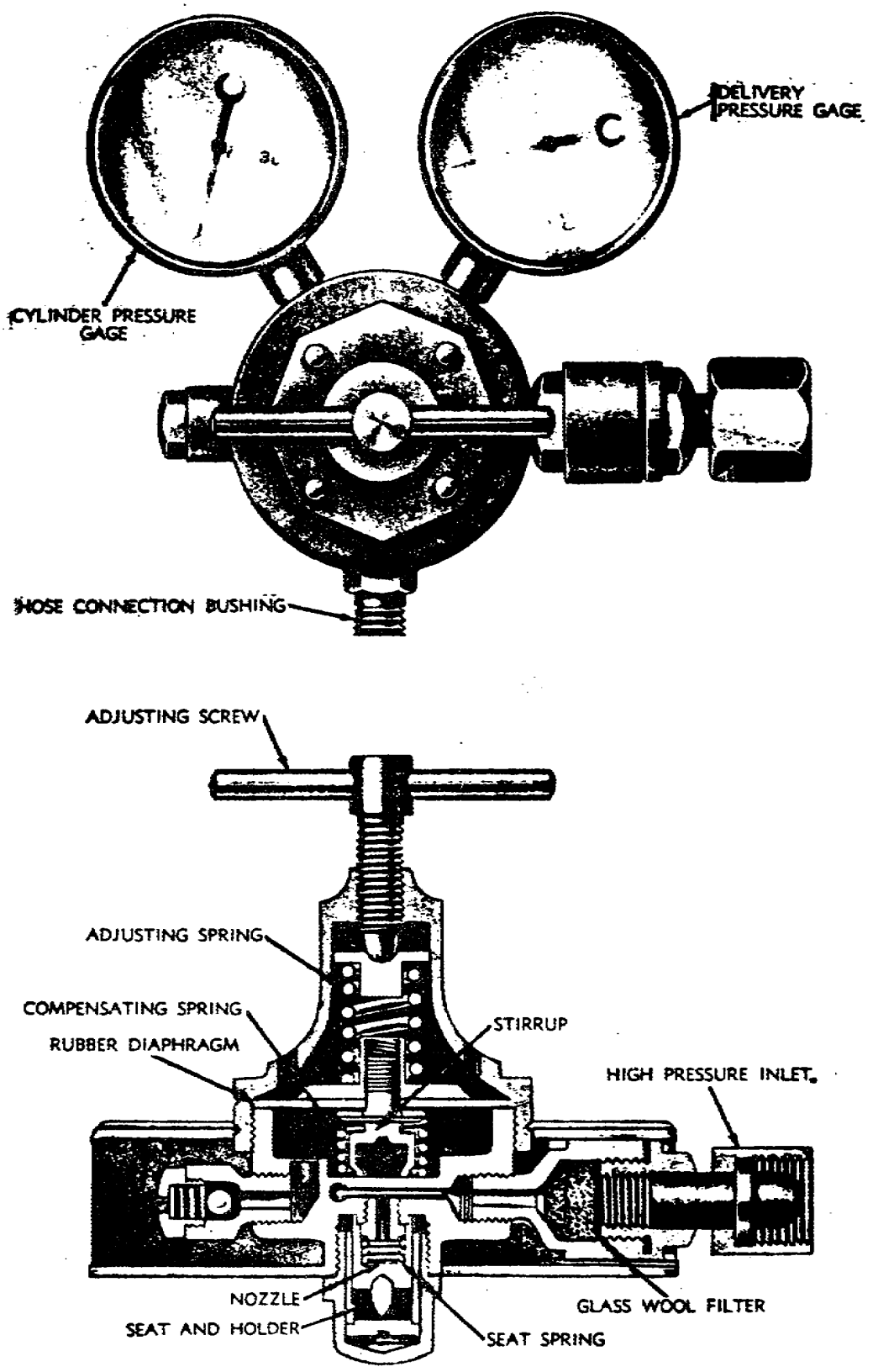


Figure 5, Single-stage regulator.

(2) Operation of single-stage oxygen regulator.

(a) The oxygen enters the regulator through the high-pressure inlet connection and passes through a glass wool filter which removes dust and dirt. The seat which closes off the nozzle is not raised until the adjusting screw is turned in. Turning in the adjusting screw applies pressure to the adjusting spring which bears down on the rubber diaphragm. The diaphragm presses downward on the stirrup and overcomes the pressure on the compensating spring. When the stirrup is forced downward, the passage through the nozzle is opened and oxygen is allowed to flow into the low-pressure chamber of the regulator. From here the oxygen passes through the regulator-outlet and the hose to the torch. A certain set pressure must be maintained in the low-pressure chamber of the regulator so that oxygen will continue to be forced through the orifices of the torch, even if the torch needle valve is open. This pressure is indicated on the working pressure gage of the regulator and depends on the position of the regulator adjusting screw. The pressure is increased by turning the adjusting screw to the right and decreased by turning to the left.

(b) Regulators used at stations to which gases are piped from an oxygen manifold, acetylene manifold, or acetylene generator have only one low-pressure gage because the pipe line pressures are usually set at 15 PSI for acetylene and approximately 200 PSI for oxygen.

(3) Two-stage oxygen regulator. The operation of the two-stage regulator is similar in principle to that of the single-stage regulator. The difference is that the total pressure decrease takes place in two steps instead of one, On the high-pressure side the pressure is reduced from cylinder pressure to intermediate pressure. On the low-pressure side the pressure is reduced from intermediate pressure to working pressure. Because of the two-stage pressure control, the working pressure is held constant and pressure adjustments during welding operations are not required.

(4) Acetylene regulator. This regulator controls and reduces the acetylene pressure from any standard commercial cylinder containing pressures up to and including 500 PSI. It is of the same general design as the oxygen regulator but will not withstand such high pressures. The high-pressure gage, on the inlet side of the regulator, is graduated from 0 to 500 PSI. The low-pressure gage, on the outlet side of the regulator, is graduated from 0 to 30 PSI. Acetylene should not be used at pressures exceeding 15 PSI.

d. Hose.

(1) The hose used to make the connection between the regulators and torch is made especially for this purpose. It is built to withstand high internal pressures. It is strong, nonporous, light, and flexible to permit ready manipulation of the torch. The rubber used in its manufacture is chemically treated to remove free sulfur so as to avoid possible spontaneous combustion. The hose is not impaired by prolonged exposure to light.

(2) The oxygen hose is green and the acetylene hose is red. The hose is a rubber tube with braided or wrapped cotton or rayon reinforcements and a rubber covering. For heavy-duty welding and cutting operations, requiring 1/4- to 1/2-inch internal diameter hose, three to five plies of braided or wrapped reinforcements are used. One ply is used in the 1/8- to 3/16-inch hose for light torches.

(3) Hoses are provided with connections at each end so that they may be connected to their respective regulator outlet and torch inlet connections. To prevent a dangerous interchange of acetylene and oxygen hoses, all threaded fittings used for the acetylene hookup are left hand and all threaded fittings for the oxygen hookup are right hand.

(4) Welding and cutting hose is obtainable as a single hose for each gas or with the hoses bonded together along their length under a common outer rubber jacket. This type prevents the hose from kinking or becoming entangled during the welding operation.

e. Oxyacetylene welding torch.

(1) The oxyacetylene welding torch is used to mix oxygen and acetylene in definite proportions and to control the volume of these gases burning at the welding tip. The torch has two needle-type valves: one for adjusting the flow of oxygen and one for adjusting the flow of acetylene. In addition, there are two tubes, one for oxygen, the other for acetylene; a mixing head; inlet nipples for the attachment of hoses; a tip; and a handle. The tubes and handle are of seamless hard brass, copper nickel alloy, stainless steel, or other noncorrosive metal of adequate strength.

(2) There are two general types of welding torches: the low-pressure or injector type and equal pressure type.

(a) In the low-pressure or injector type (fig 6) the acetylene pressure is less than 1 PSI. A jet of high-pressure oxygen is used to produce a suction effect to draw in the required amount of acetylene. This is accomplished by designing the mixer in the torch to operate on the injector principle. The welding tips may or may not have separate injectors designed integrally with each tip.

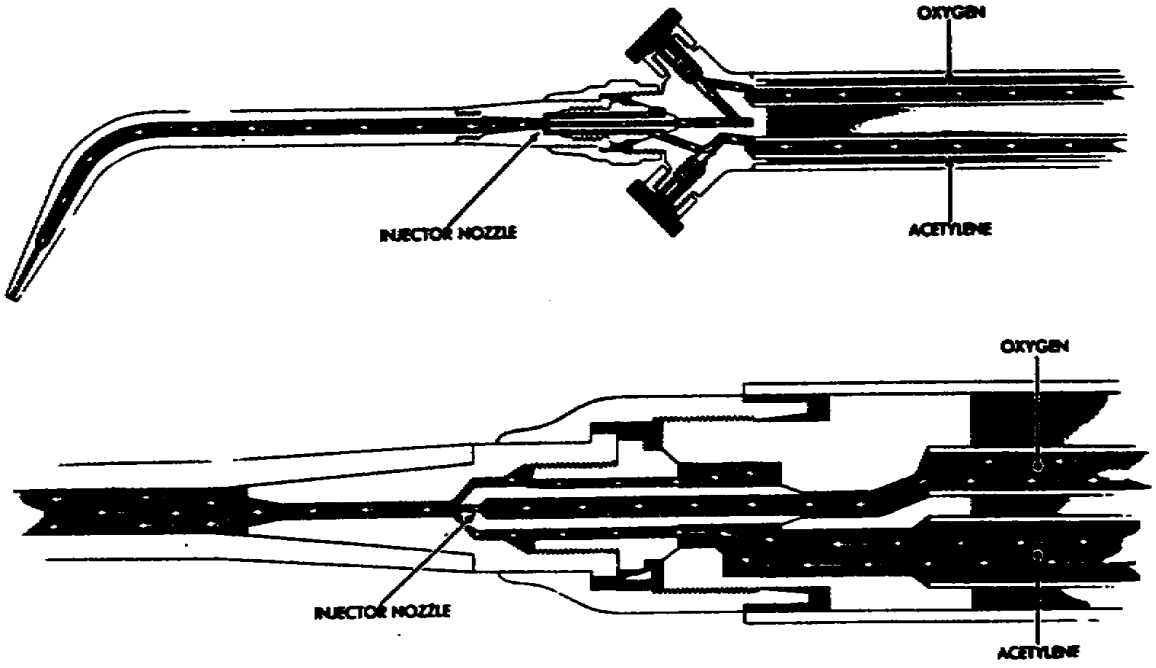


Figure 6. Mixing head for injector type welding torch.

(b) The equal pressure torch (fig 7) is designed to operate with equal pressures for the oxygen and acetylene. The pressure ranges from 1 to 15 PSI. This torch has certain advantages over the low-pressure type in that the flame desired can be more readily adjusted and, since equal pressures are used for each gas, the torch is less susceptible to flashbacks.

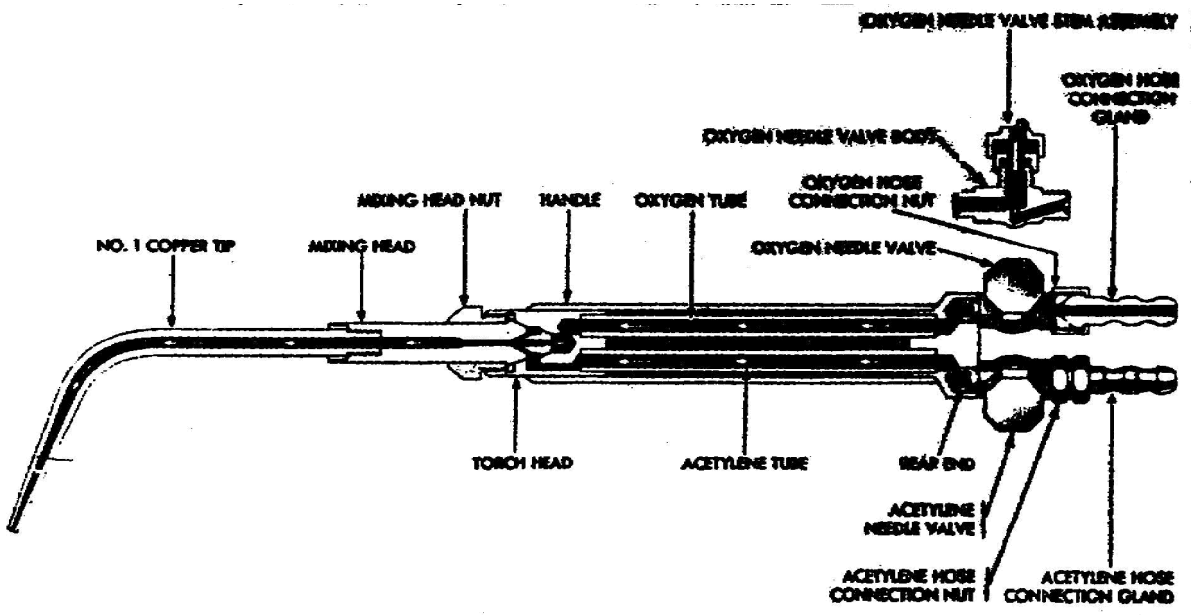


Figure 7. Equal pressure type, general purpose welding torch.

f. Welding tips and mixers.

(1) The welding tips (fig 6 and 7) are made of hard drawn electrolytic copper or 95 percent copper and 5 percent tellurium. They are made in various styles and types, some having a one-piece tip either with a single orifice or a number of orifices, and others with two or more tips attached to one mixing head. The diameters of the tip orifices differ in order to control the quantity of heat and type of flame. These tip sizes are designated by numbers which are arranged according to the individual manufacturer's system. In general, the smaller the number, the smaller the tip orifice.

(2) Mixers (fig 7) are frequently provided in tip mixer assemblies which assure the correct flow of mixed gases for each size tip. In this tip mixer assembly the mixer is assembled with the tip for which it has been drilled and then screwed onto the torch head. The universal type mixer is a separate unit which can be used with tips of various sizes.

12. SETTING UP WELDING EQUIPMENT. When setting up welding equipment it is important that all operations be performed systematically in order to avoid mistakes and possible trouble. The setting up procedures given below will assure safety to operator and the equipment.

a. Cylinders. Place the oxygen and acetylene cylinders, if they are not mounted on a truck, on a level floor and tie them firmly to a workbench, post, wall, or other secure anchorage to prevent their being knocked or pulled over. A truck loaded with equipment is shown in figure 8.

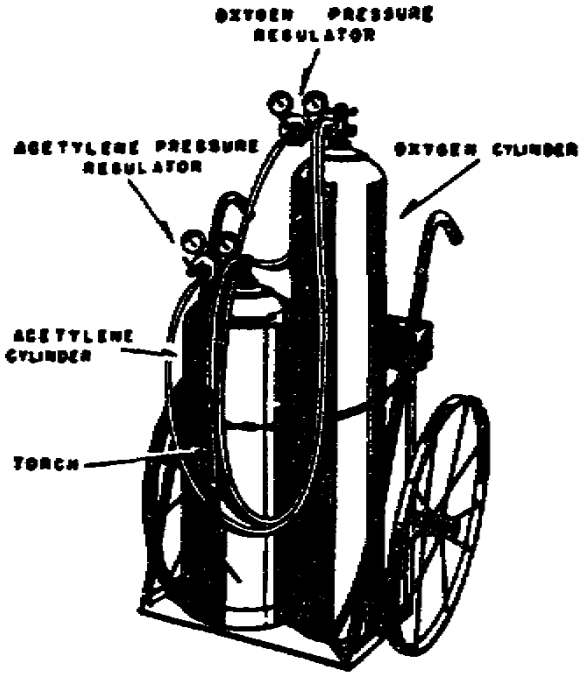


Figure 8. Complete truck, cylinders etc, with welding torch.

b. Caps. Remove the valve protecting caps. At times the caps stick in place and a wrench must be used to remove them. Quite often, tapping slightly on the side of the cap, just over the threads, will assist in removing it.

c. Opening the valves. Both the oxygen and acetylene valves should be opened slightly and then quickly closed. This will blow out any dirt or grit which may have accumulated in the cylinder valve outlet nipple. Opening the valves in this manner before the regulators are put in place also insures that the second time they are opened they will turn easier and may be opened slowly.

d. Attaching the regulators. Both the oxygen and acetylene regulators are attached to the cylinder valve outlet nipple of their respective cylinder. To prevent attaching the wrong regulator to the cylinder, the size of the nut, and sometimes the threads, differ. Be sure that these threads are not crossed and that the regulator inlet nipples are firmly in place in the outlet nipples of the cylinder valves. Screw up the regulator connecting nut with a wrench until the union is gastight.

e. Blowing out the regulators. Both adjusting screws are fully released by turning them to the left until there is no pressure on the regulator spring within the bonnet. The cylinder valves are then opened slowly, permitting the gases to enter the regulators. A slight turn to the right of each regulator adjusting screw will open the regulator valve, or seat, slightly, permitting the escape of the gases through the outlet nipples of the regulators. The adjusting screws are then released.

f. Attaching the hose. Both oxygen and acetylene hose lines are now attached to regulator outlet nipples. The oxygen hose (green) has right-hand threads and acetylene hose (red) has left-hand threads on their respective connecting nipples. This prevents their being interchanged with each other. Both are clearly marked to eliminate confusion.

g. Blowing out the hose. No dirt or grit should be allowed to remain in the hose which could be blown into the torch where it could obstruct the flow of gases. Therefore, before attaching the torch, each hose should be blown out after being attached to the regulator. Keep open flame away while this operation is being performed. The ideal way to do this would be to blow the hoses out with compressed air before attaching the hoses to either the regulator or torch. In the absence of a compressed air supply, the above should be followed, observing. caution to avoid accidental ignition of the gases.

h. Attaching the torch handle. The hoses are then screwed onto the torch handle inlet connections. Make certain they are tight. The oxygen hose is attached to right-hand threaded nipple (often marked OX) and the acetylene hose is attached to the left-hand threaded nipple (often marked AC).

i. Blowing out the torch handle. Turn both adjusting screws to the right until gas flows into the hoses. Open one valve on the torch at a time, blowing out any dirt or grit that might have accumulated in the torch handle. Close the valves quickly to prevent further escaping of the gases.

j. Attaching the tip. Select the proper size tip for the operation to be performed and secure it in place in the torch handle.

k. Testing for leaks. When the equipment is completely set up and the regulator adjusting screws are set for the correct operating pressures, it must be certain that all gas connections are "GASTIGHT". This is assured by testing each joint with a brush and soapy water. Any escaping gas will immediately produce a soap bubble.

l. Adjustment of working pressure. Adjust the acetylene working pressure by opening the acetylene needle valve in the torch and turning the regulator screw to the right; then adjust the acetylene regulator to the required pressure for the tip size to be used. Figures 9 and 10 provide pressure settings for a low-pressure or injector type torch and a balanced pressure type torch. Close the needle valve. Adjust the oxygen working pressure in the same manner.

Tip Size, No	Acetylene, PSI	Oxygen, PSI
0	1	9
1	1	9
2	1	10
3	1	10
4	1	11
5	1	12
6	1	14
7	1	16
8	1	19
10	1	21
12	1	25
15	1	30

Figure 9. Low pressure or injector type torch.

Tip size, No	Acetylene, PSI
1	2
1	2
3	3
4	3
5	3.5
6	3.5
7	5
8	7
9	9
10	12

Figure 10. Balanced pressure type torch.

Note. - Oxygen pressures are approximately the same as acetylene in the balanced pressure type torch. Pressures for specific types of mixing heads and tips are specified by the manufacturer.

13. FLAME ADJUSTMENT AND FLAME TYPES.

a. Lighting the torch. To start the welding torch hold it so as to direct the flame away from the operator, gas cylinders, hose, or any flammable material. Open the acetylene valve and ignite the gas by striking the sparklighter in front of the tip.

(1) Since the oxygen valve is closed the acetylene is burned by the oxygen in the air. There is not sufficient oxygen to provide complete combustion so the flame is smoky and produces a soot of fine unburned carbon. The acetylene flame is long, bushy, and has a yellowish color. This pure acetylene flame is unsuitable for welding.

(2) Before opening the oxygen valve, the acetylene valve should be slowly opened until the base of the pure acetylene flame is about 1/16- to 1/8-inch away from the tip face. When so adjusted the flame is stable and free from flashbacks or backfires.

(3) Slowly open the oxygen valve; the acetylene flame will shorten and return to the tip face. The flame changes to a bluish-white and forms a bright inner cone surrounded by an outer flame envelope or sheath flame. The inner cone develops the high temperature required for welding. The outer envelope contains varying amounts of incandescent carbon soot, depending on the proportions of oxygen and acetylene in the flame.

(4) The temperature produced is so high (up to 6,300°F) that the products of complete combustion (i.e., carbon dioxide and water) are decomposed into their elements. Acetylene burning in the inner cone with oxygen supplied by the torch forms carbon monoxide and hydrogen. As these gases cool from the high temperatures of the inner cone they burn completely with the oxygen supplied by the surrounding air and form the lower temperature sheath flame. The carbon monoxide burns to form carbon dioxide and the hydrogen burns to form water vapor. Since the inner cone contains only carbon monoxide and hydrogen, which are reducing in character (i.e., able to combine with and remove oxygen), oxidation of the metal will not occur within this zone.

b. Types of flames. Three types of oxyacetylene flames (fig 11) are commonly used for welding. These are neutral, reducing (or carburizing), and oxidizing flames.

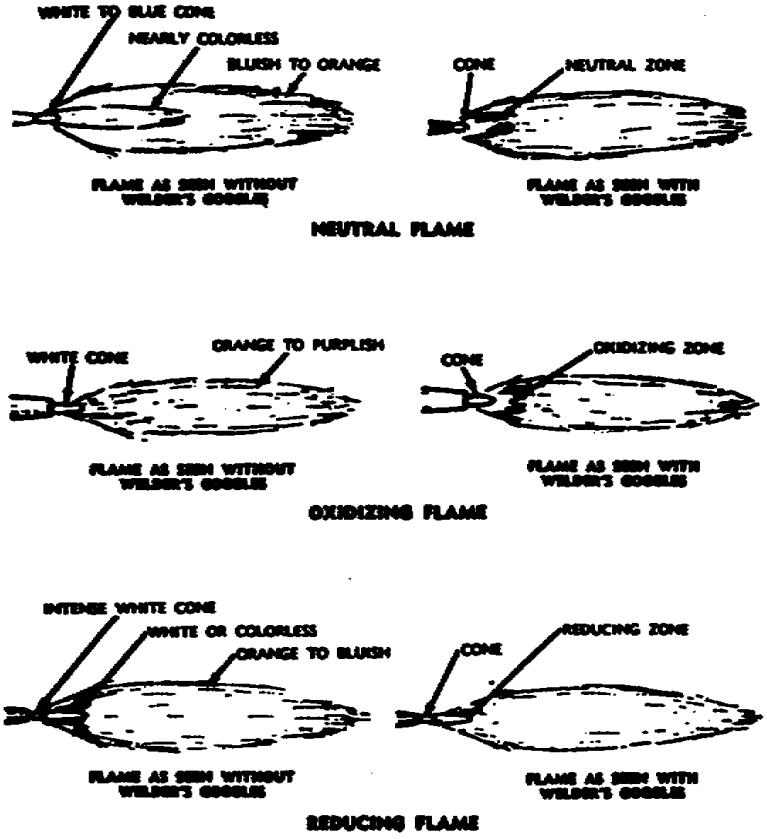


Figure 11. Oxyacetylene flames.

(1) Neutral flame.

(a) The welding flame should be adjusted to neutral before either the carburizing or oxidizing flame mixture is set. There are two clearly defined zones in the neutral flame. The inner zone consists of a luminous cone that is bluish-white. Surrounding this is a light blue flame envelope or sheath. This neutral flame is obtained by starting with an excess acetylene flame in which there is a "feather" extension of the inner cone. When the flow of acetylene is decreased or the flow of oxygen increased the feather will tend to disappear. The neutral flame begins when the feather disappears.

(b) The neutral or balanced name is obtained when the torch mixed gases consist of approximately one volume of oxygen and one volume of acetylene. It is obtained by gradually opening the oxygen valve to shorten the acetylene flame until a clearly defined inner cone is visible. For a strictly neutral flame no whitish streamers should be present at the end of the cone. In some cases it is desirable to leave a slight acetylene streamer or "feather" (1/16- to 1/8-inch long) at the end of the cone to insure that the flame is not oxidizing. The volume ratio of oxygen to acetylene in forming a neutral flame is 1.04 to 1.14. This flame adjustment is used for most welding operations and for preheating during cutting operations. When welding steel with this flame the molten metal puddle is quiet and clear. The metal flows easily without boiling, foaming, or sparking.

(c) In the neutral flame the temperature at the inner cone tip is approximately 5,850°F, while at the end of the outer sheath or envelope the temperature drops to approximately 2,300°F. This variation within the flame permits some temperature control when making a weld. The position of the flame to the molten puddle can be changed and the heat controlled in this manner.

(2) Oxidizing flame.

(a) The oxidizing flame is produced when slightly more than one volume of oxygen is mixed with one volume of acetylene. The volume ratio is 1.7 to 1.15. To obtain this type of flame the torch should first be adjusted to give a neutral flame. The flow of oxygen is then increased until the inner cone is shortened to about one-tenth of its original length. When the flame is properly adjusted the inner cone is pointed and slightly purple. An oxidizing flame can also be recognized by its distinct hissing sound. The temperature of this flame is approximately 6,300°F.

(b) When applied to steel an oxidizing flame causes the molten metal to foam and give off sparks. This indicates that the excess oxygen is combining with the steel and burning it. An oxidizing flame should not be used for welding steel because the deposited metal will be porous, oxidized, and brittle. This flame will ruin most metals and should be avoided, except as noted in (c) below.

(c) A slightly oxidizing flame is used in torch brazing of steel and cast iron. A stronger oxidizing flame is-used in the welding of brass or bronze.

(d) In most cases the amount of excess oxygen used in this flame must be determined by observing the action of the flame on the molten metal.

(3) Reducing or carburizing flame.

(a) The reducing or carburizing flame is obtained when slightly less than one volume of oxygen is mixed with one volume of acetylene. The volume ratio is 0.85 to 0.95. This flame is obtained by first adjusting to neutral and then slowly opening the acetylene valve until an acetylene streamer or "feather" is at the end of the inner cone. The length of this excess streamer indicates the degree of flame carburization. For most welding operations this streamer should be approximately twice the length of the inner cone.

(b) The reducing or carburizing flame can always be recognized by the presence of three distinct flame zones. There is a clearly defined bluish-white inner cone, a white intermediate cone indicating the amount of excess acetylene, and a light-blue outer flame envelope. This type of flame burns with a coarse rushing sound and has a temperature of approximately 5,700°F, at the inner cone tips.

(c) When a strongly carburizing flame is used for welding the metal boils and is not clear. The steel in absorbing carbon from the flame gives off heat which causes the metal to boil. When cold the weld has the properties of high carbon steel, being brittle and subject to cracking.

(d) A slight feather flame of acetylene is sometimes used for backhand welding. A carburizing flame is advantageous for welding high carbon steel, for hard facing operations, and for welding such nonferrous alloys as nickel and monel. When used in silver soldering operations only, the intermediate and outer flame cones are used. They impart a low temperature soaking heat to the parts being soldered.

14. SHUTTING DOWN WELDING APPARATUS.

a. Shut off the gases. First close the acetylene valve and then the oxygen valve on the torch. Then close the acetylene and oxygen cylinder valves.

b. Drain the regulators and hoses by the procedures outlined below.

(1) Open the torch acetylene valve until the gas stops flowing; then close the valve.

(2) Next open the torch oxygen valve to drain the oxygen regulator and hose. When gas stops flowing, close the valve.

(3) When the above operations are performed properly both high- and low-pressure gages on the acetylene and oxygen regulators will register zero.

c. Release the tension on both regulator screws by turning the screws to the left until they rotate freely.

d. Coil the hoses without kinking them and suspend them on a suitable holder or hanger. Avoid upsetting the cylinders to which they are attached.

15. WELDING RODS.

a. Welding rods are drawn or cast metal rods of various diameters for various classes of work. Oxyacetylene welding rods may be grouped into two classes: ferrous and nonferrous. In the first group are rods of steel and cast iron, while the latter covers the so-called bronzes, copper, aluminum, and nickel. The welding rod acts as a filler metal and during the process of welding is fused with the base metal. Metal from such rods forms a large portion of the actual weld metal; consequently, the rod plays a most important part in determining the quality of the finished weld.

b. Good welding rods must be of correct chemical composition and, equally important, free from foreign matter or "dirt". The metal from the rod changes somewhat in its chemical composition and its properties after passing through the welding flame. A good welding rod, naturally, has its composition so fixed as to provide for these changes; therefore, the metal in the weld will be of as good quality, or better than, the parts being joined. Good rods will melt and flow freely and will unite readily with the base metal producing sound, clean welds.

c. The behavior of a welding rod in the blowpipe flame gives a good indication of its quality. It must melt quietly and without excessive sparking. Welding rods are made in various diameters from 1/16 inch to 3/8 inch. As a rule, the diameter of the welding rod should correspond with the thickness of the material being welded.

d. Welding rods should be stored in such a way that the different kinds of rods will not get mixed up. Steel and cast iron rods should be kept dry so they will not rust. Some manufacturers apply a very thin coating of copper or grease to prevent rust.

e. In fusion welding, the welding rod is generally similar to the base metal. In bronze welding, however, the same kind of rod is used for a wide variety of base metals.

16. WELDING FLUXES.

a. General.

(1) At welding temperatures all metals oxidize (i.e., form chemical compounds with oxygen from the air) more or less rapidly and the oxides so formed act as so much "dirt." If permitted to remain in the finished weld, the oxide would seriously reduce the strength of the weld and might even make it useless.

(2) In welding steel, oxides of the various elements form and unite together into a slag that fuses at a lower temperature than that required to melt the steel. This slag tends to float to the surface of the weld and, with care on the part of the operator, these oxides can be collected on the top of the puddle of molten metal and thus removed from the joint.

(3) In cast iron and aluminum welding particularly, and in welding practically all of the common metals except steel, the temperature of the molten metal is considerably below the melting point of the oxides that form so that the latter remain in the weld as solid particles. In order to get rid of these oxides a flux is used. This is a mixture of various chemicals that at welding temperatures will unite with the oxides to form an easily fusible slag.

(4) Since the oxides of the different metals vary widely in physical properties, no one flux is suitable for all metals.

(5) The production of a good welding flux requires a knowledge of chemistry at high temperatures as well as experience in welding. Use prepared fluxes of reputable manufacturers, rather than experiment with unsatisfactory substitutes.

b. Properties.

(1) Prevents oxidation of the base metal by virtue of its protective coating.

(2) Dissolves oxides that are formed during heating.

(3) Promotes capillary action between the metals being joined.

(4) Fluxes are not designed to remove oil, grease, or other foreign substances; therefore, surfaces of the metal should be cleaned prior to the application of the flux.

(5) Fluxes are used in paste, dry powder, saturated solution, or in a volatile form.

c. Use. Figure 12 reflects the type of flame adjustment, type of flux, and type of welding rod to be used for different types of metal.

17. WELDING TECHNIQUES.

a. Hold the torch in such a position so that the tip is in line with the weld and at an angle of about 45° to it.

b. The angle between the rod and flame should be approximately 90°.

METAL	FLAME ADJUSTMENT	FLUX	WELDING ROD
Steel, cast	Neutral	No	Steel
Steel pipe	Neutral	No	Steel
Steel plate—low carbon	Neutral	No	Steel
Steel sheet—low carbon	Neutral	No	Steel
	Slightly oxidizing	Yes	Bronze
High-carbon steel	Carburizing	No	Steel
Manganese steel	Slightly oxidizing	No	Base metal composition
Wrought iron	Neutral	No	Steel
Galvanized iron	Neutral	No	Steel
	Slightly oxidizing	Yes	Bronze
Cast iron, gray	Neutral	Yes	Cast iron
	Slightly oxidizing	Yes	Bronze
Cast iron, malleable	Slightly oxidizing	Yes	Bronze
Chromium nickel	Slightly oxidizing	Yes	Bronze
Stainless steel (18-8)	Slightly carburizing	No	Stainless steel (18-8)
	Neutral	Yes	Stainless steel (18-8)
Aluminum	Slightly carburizing	Yes	Aluminum
Brass-bronze	Slightly oxidizing	Yes	Brass or bronze
Copper	Slightly oxidizing	No	Same as base metal
	Neutral	Yes	Same as base metal or bronze
Hard surfacing	Slightly carburizing	No	Bare hard surfacing rod

Figure 12. Flame, flux, and welding rod index.

c. Pass the flame over the metal several times in order to preheat the metal slightly; then direct the flame steadily upon the spot where the weld is to begin.

d. Keep the end of the luminous cone about one-sixteenth of an inch away from the metal.

e. Just before the metal begins to melt, bring the end of the welding rod under the flame. If this action is timed correctly, both the rod and base metal will melt at the same time and form a puddle of molten metal.

f. Care should always be taken to keep the rod within the molten puddle since the rod will stick to the plate if it touches the cooler edges.

g. On metal of 1/8-inch thickness, the bead should be approximately 3/8-inch wide.

h. The filler metal from the welding rod is added by dipping the end of the rod into the molten puddle of metal. Movement of the torch should be styled to suit the individual.

i. Before moving forward, be sure that the added material is actually being fused to the base metal and not merely being laid on the surface in droplets. If the weld is carried forward too rapidly, the metal will not fuse together, if progression is too slow, the metal is very likely to be burned.

j. Penetration of the weld all the way through the seam to the bottom edge is one of the most important requirements of welding.

EXERCISE

36. What advantage does a two-stage oxygen regulator have over a single-stage regulator?

a. Better adjustment can be obtained with a single-stage regulator
b. Working pressure is held constant during welding operations
c. Two-stage regulator is safer

37. To prevent dangerous interchange of oxygen and acetylene hoses what measures have been taken?

a. Threaded fittings for oxygen hookup are right-handed
b. Threaded fittings for acetylene hookup are right-handed
c. Oxygen hoses are red and acetylene hoses are green

38. When adjusting the oxygen acetylene torch flame, which type of flame would have a ratio of slightly less than one volume of oxygen mixed with one volume of acetylene (0.85 to 0.95)?

a. Neutral
b. Oxidizing
c. Reducing or carburizing

39. What effect do oxides have in a finished weld?

a. Causes the bond to be stronger
b. Removes grease and oil from surface to be welded
c. Seriously reduces the strength of the weld

40. What should the approximate angle between the welding rod and the flame be?

a. 45°
b. 90°
c. 60°

41. What is the proper time to bring the welding rod under the flame during a welding operation?

a. Heat the base metal and welding rod at the same time
b. Just before the base metal begins to melt
c. After the base metal has formed a puddle

SECTION IV. OXYGEN ACETYLENE CUTTING

18. GENERAL.

a. If iron or steel is heated to its kindling temperature (not less than 1,600°F), and then brought in contact with oxygen, it burns or oxidizes very rapidly. The reaction of oxygen with the iron or steel forms iron oxide and gives off considerable heat. This heat is sufficient to melt the oxide and some of the base metal; consequently, more of the metal is exposed to the oxygen stream. This reaction of oxygen and iron is utilized in the oxyacetylene cutting process. A stream of oxygen is impinged on the metal surface, which has been heated to the kindling temperature by the preheating flames at the torch tip. The hot metal reacts with oxygen, generating more heat and melting, and the molten metal and oxide are swept away by the rapidly moving stream of oxygen. The oxidation reaction continues and furnishes heat for melting another layer of metal. The cut progresses in this manner. The principle of the cutting process is shown in figure 13.

b. Theoretically, the heat created by the burning iron would be sufficient to heat adjacent iron red hot so that the cut, once started, could be continued indefinitely with oxygen only, as is done with the oxygen lance. In practice, however, excessive heat absorption at the surface, caused by dirt, scale, or other substances, makes it necessary to keep the preheating flames of the torch burning throughout the operation.

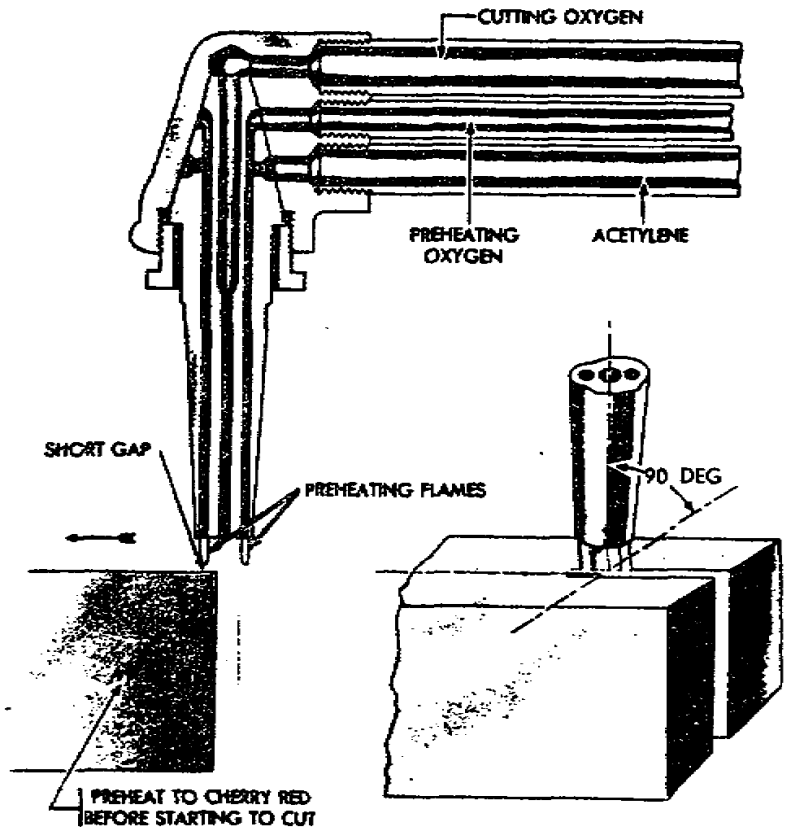


Figure 13. Starting a cut and cutting with a cutting torch.

19. EQUIPMENT.

a. Cutting torch.

(1) The cutting torch (fig 14) is an apparatus for mixing oxygen and acetylene in definite proportions, burning the mixture in preheating flames that are allowed to impinge upon the work, and directing a jet of high-pressure oxygen to sever the ferrous material along the line of cut. In appearance, the hand-cutting torch is somewhat similar to a welding torch, but it differs in its construction and method of control. It consists principally of a handle, connecting tubes, and head. The handle is equipped, at the rear end, with oxygen and acetylene hose connections. A needle valve in the acetylene inlet connection controls the supply. The oxygen furnished to the preheating flames is regulated by a preheat valve on the side of the handle. A high-pressure oxygen valve, operated by a trigger or lever, controls the cutting oxygen.

(2) In some cutting torches, the preheating oxygen and acetylene do not mix until they are in the cutting tip. Such torches have three gas tubes: one for high-pressure oxygen (top), one for preheating oxygen (middle), and one for acetylene (bottom). In other cutting torches, the preheating oxygen and acetylene premix in the torch body in a common mixing chamber. Such torches have only two gas tubes: one for high-pressure oxygen (top) and one for the mixture of gases (bottom).

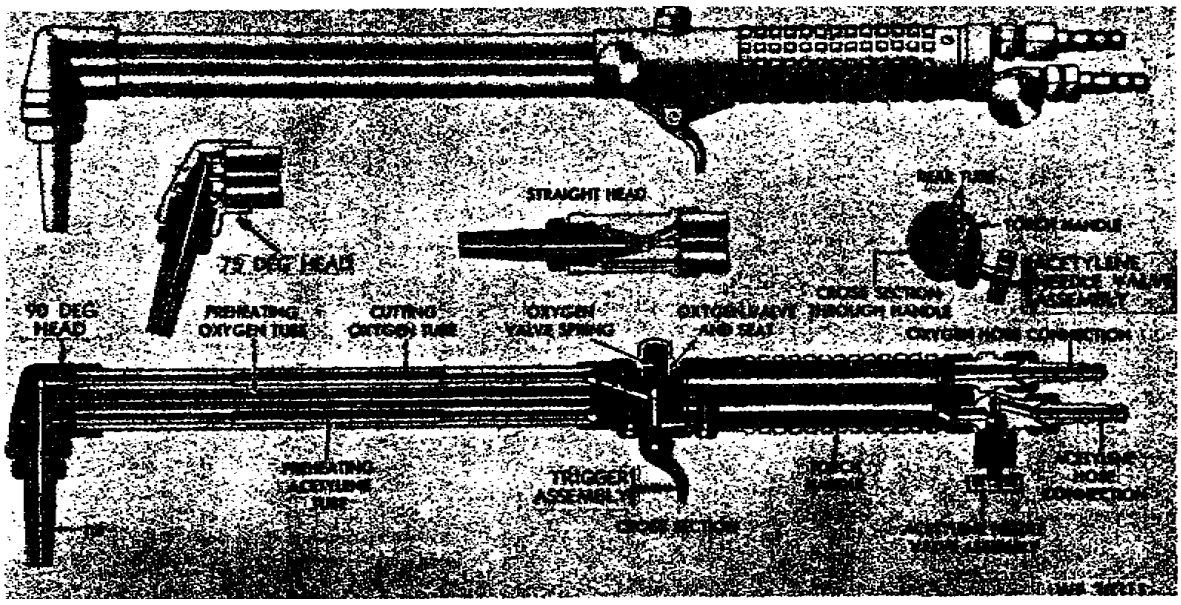


Figure 14. The cutting torch.

(3) Cutting torches are furnished with a 90° or 75° angle head, or straight head, to suit the requirements.

b. Cutting attachment. A cutting attachment that is fitted to a welding torch in place of the welding head is shown in figure 15.

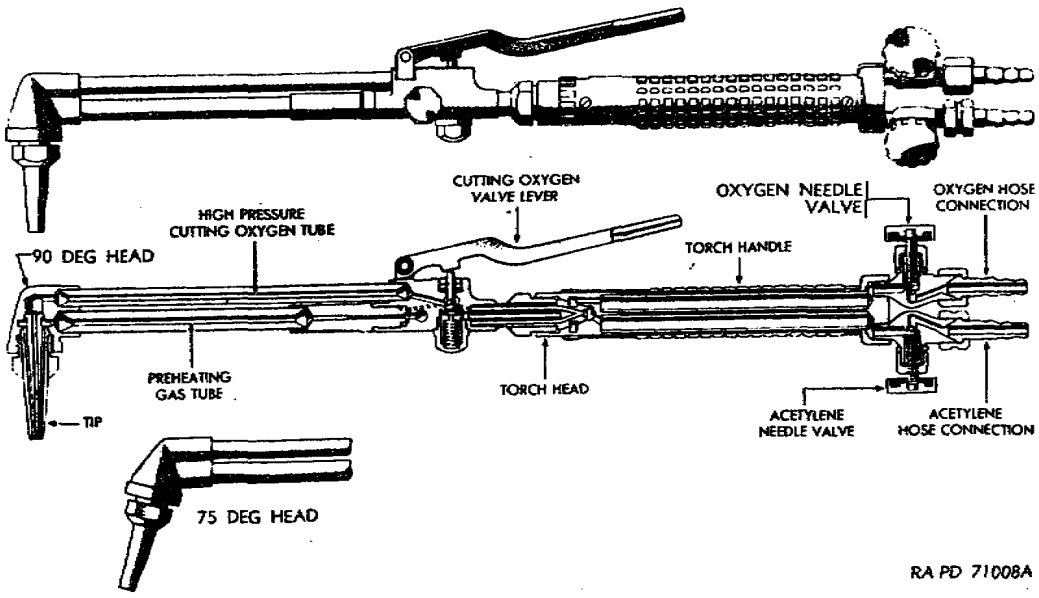


Figure 15. Cutting attachment for welding torch.

c. Tips. There is a wide variety of cutting tip styles and sizes available to suit various types of work. The thickness of the material to be cut generally governs the selection of the tip. The cutting oxygen pressure, cutting speed, and preheating intensity should be controlled to produce narrow, parallel sided kerfs. Cuts that are improperly made will produce ragged, irregular edges with adhering slag at the bottom of the plates. Cutting tip numbers, gas pressures, and hard cutting speeds used for cutting mild steel up to 12 inches thick are shown in figure 16.

Note. - Various manufacturers do not adhere to the numbering of tips as set forth in this figure; therefore, some tips may carry different identification numbers.

Plate Thickness (Inch)	Cutting Tip Size Number	Oxygen Pressure (P.S.I.)	Acetylene Pressure (P.S.I.)	Hand Cutting Speed Inches Per Minute
1/4	0	30	3	16.0 to 18.0
3/8	1	30	3	14.5 to 16.5
1/2	1	40	3	12.0 to 14.5
3/4	2	40	3	12.0 to 14.5
1	2	50	3	8.5 to 11.5
1-1/2	3	45	3	6.0 to 7.5
2	4	50	3	5.5 to 7.0
3	5	45	4	5.0 to 6.5
4	5	60	4	4.0 to 5.0
5	6	50	5	3.5 to 4.5
6	6	55	5	3.0 to 4.0
8	7	60	6	2.5 to 3.5
10	7	70	6	2.0 to 3.0
12	8	70	6	1.5 to 2.0

Figure 16. Oxyacetylene cutting information.

d. Protective clothing and equipment.

(1) Clothing manufactured of wool should be worn in preference to cotton since wool is not easily burned or damaged by weld-metal spatter.

(2) Asbestos cloth or leather aprons or jackets should be worn to provide protection against the spatter of molten metal, especially when welding in the vertical or overhead positions.

(3) High-upper shoes and cuffless pants should be worn to prevent spatter from collecting in the cuffs and to protect the feet.

(4) Gauntlet gloves that are flameproof, preferably of leather, will protect the arms and hands from weld spatter. These must be in good condition and free from oil and grease to prevent them from being ignited or charred by molten metal or hot spatter.

(5) Goggles, spectacles, or helmets with colored lenses should always be worn when cutting or welding by any process. The colored lenses of the correct shade, usually blue or brown, give protection from the glare or harmful rays encountered in arc welding and allow the operator to see the work clearly. A protective clear cover glass protects the colored lens from damage and must be changed when damaged or severely pitted by molten spatter.

2O. OPERATION OF CUTTING EQUIPMENT.

a. Setting up and shutting down a cutting outfit. The rules for setting up and shutting down a cutting outfit are the same as for a welding outfit, in practically every detail, and should be carefully adhered to. Particular care should be taken to avoid oil, grease, or other easily oxidizable lubricant on fittings.

b. Selection of cutting tip. The correct style and size ,of cutting tip to use is determined, primarily, by the kind of material to cut, its thickness, and its surface condition. Some materials are harder to cut than others and require different cutting tips. The main factor that controls the size of the cutting orifice to be used, however, is the thickness to be cut. Very rusty, scaly, or painted surfaces offer greater resistance to the preheating flames and require a higher intensity of heat. Refer to figure 16 as a guide in selecting the proper tip.

c. Cutting oxygen pressure, cutting speed. The use of oversize cutting tips and excessive oxygen and acetylene pressures is uneconomical. A cutting tip with a large cutting oxygen orifice necessarily cuts a wider kerf and consumes more oxygen than a tip with a smaller orifice, even if lower oxygen pressure is employed. Cutting oxygen pressure, of itself, avails little beyond forcing sufficient oxygen into the cut to oxidize the metal in its path and blow away the resulting oxide and unconsumed molten iron. On the other hand, excessive pressure does cause the cutting oxygen jet to swirl and spread out after leaving the tip, thus producing a wider kerf with uneven sides and increasing oxygen consumption. For maximum efficiency, cutting tips should be operated at, or near to, normal capacity but not beyond. This includes normal gas pressures and cutting speeds that utilize the cutting oxygen jet to best advantage for producing the quality of cut desired.

d. Starting the cut. In most cases, cuts are started at the edge of the piece with the cutting torch held lightly, but steadily, so that the ends of the preheating flame cones are about 1/16 inch above the surface of the material. When a spot of metal at the top of the edge has been heated to a cherry red, the trigger or lever controlling the cutting oxygen jet is pressed and cutting begins.

e. Piercing holes. When starting a cut in the metal away from the edge, or in piercing a hole, more time is usually consumed in bringing the spot of metal to the kindling temperature than with the edge starting method. After the spot is sufficiently heated, the torch is raised about 1/2 inch above the normal position for cutting and the cutting oxygen is turned on slowly. As soon as the plate is perforated, the torch is again lowered to the normal height above the work and the cut is completed. In piercing holes, care must be taken to avoid slag plugging the cutting orifice. Drilled holes are used in certain cases, particularly, to form a straight, smooth, starting edge for a heavy internal cut.

f. Hand cutting. In hand cutting, the torch is held steadily, but not tightly, with the left hand supporting it a few inches back of the head and the right hand on the handle in position to operate the cutting oxygen trigger or lever with the forefinger. As in all manual arts, the results obtained depend largely upon the skill of the operator. Fortunately, the operation of hand cutting is relatively simple. The average conscientious operator soon acquires proficiency. He must learn to hold the torch at the proper height above the work without wavering and to advance it uniformly at correct speed along the line of cut. If the torch head wavers from side to side a wider kerf will be made, the speed will be reduced, and the oxygen consumption will be increased. If the torch is moved along the line of cut at an irregular speed, the cutting will be slowed down and the gas consumption will be increased. Poor quality cuts result in either case. For best workmanship, the. operator should look down into the cut, as it progresses, and watch the drag or amount which the cut curves backward in a direction opposite to the travel. He should

take care that the flow of slag or oxide is clean and unimpeded through the metal. The torch should be moved forward just fast enough to allow oxidation to take, place clear through the material, as the cut progresses.

g. Procedure (general}.

(1) Attach the proper cutting tip, for the thickness of the metal to be cut, to the torch and adjust the oxyacetylene pressure in accordance with the torch-cutting instructions (fig 16).

(2) Adjust the preheating flame to neutral.

(3) Hold the torch firmly with one hand in such a manner as to permit the operation of the cutting-oxygen lever or trigger with the same hand. Use the other hand to steady the torch head and maintain its position in relation to the work. Hold the torch perpendicular to the work with the inner cones of the preheating flames about 1/16 inch above the end of the line to be cut. Hold the torch stationary in this position until the spot has been raised to a bright red heat. Then, open the cutting-oxygen valve slowly but steadily over the line to be cut.

(4) If the cut has been started properly a shower of sparks will fall from the opposite side of the work. The movement of the torch, along the line of the cut, should be just fast enough for the cut to continue to penetrate the work completely. When done properly, the cut will be clean and narrow, similar to one made by a saw.

(5) When cutting billets, round bars, or heavy sections, time and gas are saved if a bur is raised with a chisel at the point where the cut is to start. This small portion. will heat quickly and cutting will start immediately. A welding rod can also be used to start a cut on heavy sections, and when so used it is called a "starting rod".

h. Cutting steel and cast iron.

(1) General. Plain carbon steels, with a carbon content not exceeding 0.25 percent, can be cut without special precautions other than those required to obtain cuts of good quality. On the other hand, certain steel alloys develop high resistance to the action of the cutting oxygen making it difficult, and sometimes impossible, to propagate the cut without the use of special techniques.

(2) High-carbon steels. The action of the cutting torch on these metals is similar to a flame-hardening procedure, inasmuch as the metal adjacent to the cutting area is hardened by being heated above its critical temperature and quenched by the adjacent mass of cold metal. This condition can be minimized or overcome by preheating the part: at 500°F to 600°F before the cut is started.

(3) Waster plate on alloy steel. The cutting action on an alloy steel is difficult to cut by the usual procedure, and can be improved by clamping a mild steel "waster plate" tightly to the upper surface and cutting through both thicknesses. This waster plate method will cause a noticeable improvement in the cutting action because the molten steel dilutes or reduces the alloying content of the base metal.

(4) Chromium and stainless steels. These and other allow steels that heretofore could only be cut by a melting action, rather than by rapid oxidation, can now be cut by the introduction of iron powder or a special nonmetallic powdered flux into the cutting-oxygen stream. The iron powder oxidizes quickly and liberates a large quantity of heat. This high heat, in turn, melts the refractory oxides which normally protect the steel from the action of oxygen. These molten oxides are flushed from the cutting face and the cutting oxygen is enabled to, act upon the iron remaining in the steel. The nonmetallic flux, introduced into the cutting-oxygen stream, combines chemically with the refractory oxides producing a slag of a lower melting point that is washed or eroded out of the cut; thus, exposing the steel to the action of the cutting oxygen.

(5) Cast iron. Cast iron melts at a temperature lower than its oxide; therefore, in the cutting operation, the iron tends to melt rather than to oxidize. For this reason, the oxygen jet is used to wash out and erode the molten metal when cast iron is being cut. To make this action effective, the cast iron must be preheated to a high temperature and much heat must be liberated deep in the cut. This is affected by adjusting the preheating flame so that there is an excess of acetylene. The length of the acetylene streamer and the procedure for advancing the arc are shown in figure 17. The use of mild iron flux to maintain a high temperature in the recesses of the cut is also effective.

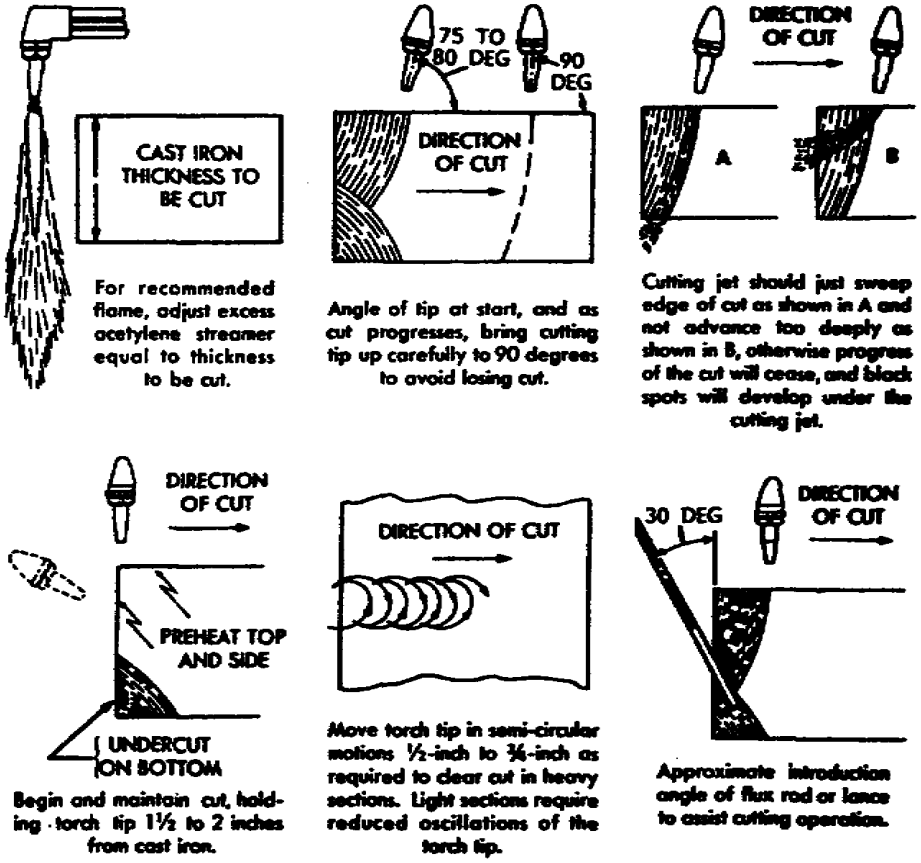

CAST IRON THICKNESS TO BE CUT
For recommended flame, adjust excess acetylene streamer equal to thickness to be cut.
75 TO 80 DEG
90 DEG
DIRECTION OF CUT
Angle of tip at start, and as cut progresses, bring cutting tip up carefully to 90 degrees to avoid losing cut.
DIRECTION OF CUT
A
B
Cutting jet should just sweep edge of cut as shown in A and not advance too deeply as shown in B, otherwise progress of the cut will cease, and black spots will develop under the cutting jet.
DIRECTION OF CUT
PREHEAT TOP AND SIDE
UNDERCUT ON BOTTOM
Begin and maintain cut, holding torch tip 1½ to 2 inches from cast iron.
DIRECTION OF CUT
Move torch tip in semi-circular motions ½-inch to ¾-inch as required to clear cut in heavy sections. Light sections require reduced oscillations of the torch tip.
30 DEG
DIRECTION OF CUT
Approximate introduction angle of flux rod or lance to assist cutting operation.

Figure 17. Procedure for oxyacetylene cutting of cast iron.

EXERCISE

42. The thickness of the material to be cut governs the selection of a cutting tip. What size tip would be used to cut a plate 3/4 of an inch thick?

a. No 2
b. No 1
c. No 3

43. After the metal is sufficiently heated, how high is the torch raised from the metal to pierce a hole ?

a. 1/4 inch
b. 1/8 inch
c. 1/2 inch

44. When cutting billets, round bars, or heavy sections with a cutting torch, what can be done to save time and gas?

a. Raise a bur with a chisel at the start of the cut
b. Use an extra large tip
c. Preheat material to a dull red color

SECTION V. BRAZING

21. GENERAL. Brazing is a group of welding processes in which fusion is produced by heating to a suitable temperature above 800°F; also, by using a nonferrous filler metal having a melting point below that of the base metals. Filler metal is distributed between the closely fitted surfaces of the joint by capillary attraction. Torch brazing will be the only process covered in this section. Other types of brazing processes are shown across the top portion of figure 1 of this lesson.

22. PRINCIPLES.

a. Brazing and hard soldering. Brazing is not a true welding operation, but a method for joining metals. The oxyacetylene welding torch is frequently used in brazing operations where the brazing material is in the form of spelter. It is also effective in hard-soldering fittings to copper pipe that is to be used at temperatures where soft solder ordinarily would not be satisfactory, for conditions where greater joint strength than that provided by soft solder is needed, or for corrosion-resistant joints.

b. Metallurgy of braze welding.

(1) The bond between two plates which have been brazed together, in most cases, will produce an adherence stronger than the base metal itself.

(2) It has been found that three distinct forces act to maintain adherence.

(a) Tinning - A clean metal surface will receive a thin film of molten metal of low surface tension. The bond thus produced depends on the action of the molecular forces at the interface between the copper alloy brazing material and the base metal,

(b) Alloying - A diffusion of the constituents of the filler - copper, zinc, tin, and others - into the base metal and a corresponding diffusion of base metal constituents into the filler metal takes place in a narrow zone at the interface between the copper brazing alloy and the base metal. The base metal crystallizes at the interface and, when examined under a microscope, shows a diffusion of the copper alloy brazing material constituents into the crystal grains and an alloying of the filler metal with the base metal.

(c) Intergranular penetration - The action of the molten copper-alloy filler material on the base metal surface tends to open the crystal grain structure of the base metal surface and allows the filler metal to penetrate the base metal along the grain boundaries.

c. Brazing rod.

(1) Brazing rod is made up of a brass alloy containing approximately 60 percent copper and 40 percent zinc.

(2) About 1 percent of tin, iron, manganese, and silicon is often added to improve the flow characteristics, decrease fumes, deoxidize, and increase the hardness in the finished weld.

d. Fluxes. The fluxes used for braze welding should be oxidizing in character in order to remove oxide films from the surface of the base metal. Otherwise, the capillary flow of the filler metal will not take place without overheating.

e. Advantages of braze welding.

(1) This process requires less preheating, permits greater welding speed, demands a shorter cooling-off period, and is less likely to crack metals, such as cast iron, during the braze welding operation.

(2) There is no splash or weld spatter to worry about and low temperatures minimize distortion.

(3) The completed joint requires little or no finishing.

(4) Brazing technique does not require as much skill as the technique required for fusion welding.

f. Disadvantages of braze welding.

(1) If the joint is to be exposed to corrosive media, the filler metal must have the required corrosion-resistant characteristics.

(2) All brazing alloys lose strength at elevated temperatures.

(3) If the joint is to be painted, all traces of the flux must be removed.

g. Torch brazing.

(1) The oxyacetylene flame is perhaps the most common method of heating the parts to be brazed and has the following advantages:

(a) Initial cost of the equipment is low in comparison to electric arc welding equipment.

(b) Heating can be localized.

(c) Method is applicable to many types of assemblies.

(d) It is an extremely flexible process.

(2) This method of heating also has the following limitations:

(a) Procedure is relatively slow.

(b) Temperature control is difficult.

(c) The flame cannot be easily applied to assemblies having multiple or inaccessible joints.

(3) Flames resulting from a combination of oxygen and city gas or any of the bottled gases, such as butane or propane, give a much greater heat and when the torch is properly designed give excellent results.

(4) The oxyacetylene flame is to be preferred to the others. However, the flame is intense and must be kept in motion in order to avoid overheating or melting the work.

(5) A slightly oxidizing flame should be used for capillary brazing. A highly oxidizing flame retards wetting and flow characteristics of the brazing alloy.

(6) The size of the torch tip selected should be large enough to minimize the preheating time, but not so large as to melt the edges of the base metal during the brazing operations.

(7) The bond strength depends directly upon the proper heating of the base metal and the proper adding of the filler rod metal.

(8) To avoid overheating, the tip is held at a small angle to the work surface. The best results are obtained by using a slightly oxidizing flame, heating to the correct temperature, and applying small quantities of the filler rod material only as needed. This is done by keeping the filler rod near enough to the flame so that the rod will maintained at a temperature near its melting point.

(9) The filler rod metal has a tensile strength ranging from two to three times the tensile strength of the junction zone and, in many cases, a strength greatly in excess of such metals as cast iron. The tensile strength is approximately 35,000 PSI.

(10) Parts which are brazed must not be moved in any way that will place a strain on the joint until the filler metal has solidified completely; otherwise, the filler metal may form cracks and the brazed joint will fail.

23. JOINT PREPARATION.

a. The strength of a brazed joint depends directly upon the bond area (fig 18). This area may be increased for additional strength by beveling the edges of the joint or by depositing a wide face weld.

b. On plates three-sixteenth inch or more in thickness, it is generally advisable to bevel the plate edges to form a single-vee groove with a 90° included angle.

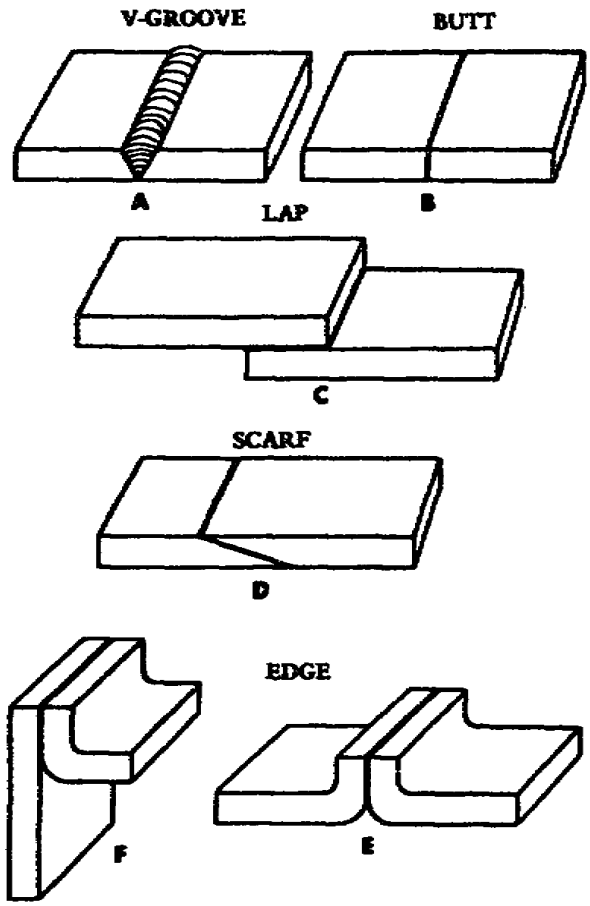


Figure 18. Joint designs.

c. When brazing or welding material one-sixteenth of an inch or less in thickness, it is impractical to bevel the joint edges since this would add very little to the bond area. A square-faced butt joint with an increased bond area, obtained by depositing filler material on a wide faced area, is more suitable.

d. In order to obtain the maximum bond strength, the joint surfaces must be bright and free from oil, rust, paint, or other foreign matter. The edges to be joined must be cleaned on both the bottom and upper surface.

24. APPLICATION OF FILLER ROD.

a. If the base metal is overheated, the filler metal will become overheated and this will result in a porous deposit. Overheating will also cause the filler metal to collect in little globules, which are driven away by the force of the flame.

b. If the temperature of the base metal is too low, the filler metal does not flow ahead by itself.

c. The best results are obtained by using a slightly oxidizing flame, heating to the correct temperature, and then applying small quantities of the filler metal only as required.

25. BRAZING GRAY CAST IRON.

a. Gray cast iron can be brazed with very little or no preheating. For this reason, broken castings that would otherwise need to be dismantled and preheated can be brazed in place, A nonferrous filler metal such as naval brass (60 percent copper, 39.25 percent zinc; 0.75 percent tin) is satisfactory for this purpose. A sufficiently high strength bond cannot be obtained with silver brazing alloys. The melting point of the nonferrous filler metal is several hundred degrees lower than the cast iron; consequently, the work can be accomplished with a lower heat input, the deposition of metal is greater, and the brazing can be accomplished faster. Because of the lower heat required for brazing, the thermal stresses developed are less severe and stress relief heat treatment is usually not required.

b. The preparation of large castings for brazing is much like that required for welding with cast iron rods. The joint to be brazed must be clean and the part must be sufficiently warm to prevent chilling of the filler metal before sufficient penetration and bonding are obtained. When possible, the joint should be brazed from both sides to insure uniform strength throughout the weld. In heavy sections the edges should be beveled to form a 60° to 90° V.

26. SILVER (BRAZING) SOLDERING.

a. Silver brazing, frequently called "silver soldering," is a low temperature brazing process with rods having melting points ranging from 1,145° to 1,650°F. This is considerably lower than that of the copper alloy brazing filler metals. The strength of a joint made by this process is dependent on a thin film of silver brazing filler metal.

b. Silver brazing filler metals are composed of silver with varying percentages of copper, nickel, tin, and zinc. They are used for joining all ferrous and nonferrous metals except aluminum, magnesium, and other metals which have too low a melting point.

c. It is essential that the joints be free of oxides, scale, grease, dirt, or other foreign matter. The surfaces, other than cadmium plating, can be easily cleaned mechanically by wire brushing or an abrasive cloth; chemically by acid pickling or other means. Extreme care must be used to grind all cadmium surfaces to the base metals since cadmium oxide formed by overheating and melting of the silver brazing alloys is highly toxic.

d. Flux is generally required. The melting point of the flux must be lower than the melting point of the silver brazing filler metal so that it will clean the base metal and properly flux the molten metal. A satisfactory flux should be applied by means of a brush to the parts to be joined and also to the silver brazing filler metal rod.

e. When silver brazing by the oxyacetylene process, a slightly reducing flame is desirable. The outer envelope of the flame, not the inner cone, should be applied to the work. The cone of the flame is too hot for this purpose. Joint clearances should be between 0.002 and 0.005 inch for best filler metal distribution. A thin film of filler metal in a joint is stronger and more effective; a fillet build up around the joint will increase its strength. Some joints which can be used are shown in figures 18 and 19.

f. The base metal should be heated until the flux starts to melt along the line of the joint; the filler metal is not subjected to the flame but is applied to the heated area of the base metal just long enough to flow the filler metal completely into the joint. If one of the parts to be joined is heavier than the other, the heavier part should receive the most heat. Also, parts having high heat conductivity should receive more heat.

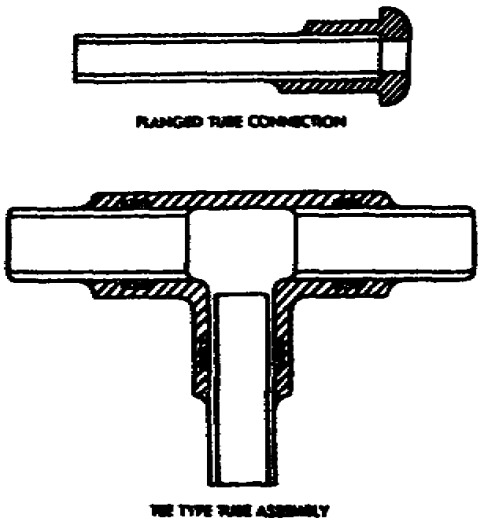


Figure 19. Silver brazing joints.

SECTION VI. SOLDERING

27. GENERAL.

a. Soldering is a method of bonding together two pieces of metal by the use of an alloy (solder) of comparatively low melting point. The type of alloy to be used (soft or hard solder) depends upon the metals to be joined; however, the solder must always melt at a lower temperature than the base metals. The nearer the melting points of the solder and the metal being soldered, the stronger the completed joint will be.

b. Soldering should not be confused with welding. In the welding process, the two metals to be joined are actually fused together; in the soldering process, the base metals are not melted but are merely coated (tinned) with the soldering alloy and then "sweated" together or joined by the application of heat. The strength of the bond between the solder and the base metal is both physical and chemical in nature. The solder penetrates the pores of the base metal causing the physical bond, and the heat used in the soldering process causes a surface reaction (chemical bond) between the chemical elements of the solder and those in the metal being soldered.

c. Soldered joints should not be relied upon for extra strength. However good they may be, they must not be subjected to excessive vibrations, severe shocks, or heavy loads. The primary purpose of a soldered joint is to hold two or more pieces of metal in close contact, such as may be required for sealing and solidifying a joint. Strength may be obtained by interlocking seams, crimping, riveting, etc.

28. TYPES OF SOLDERING. The two methods of soldering in common use are soft soldering and hard soldering. Although the basic principles of each method are the same, each serves its own special purpose.

a. Soft soldering. Soft soldering is a comparatively low-temperature method of joining two pieces of metal; it is restricted to jobs subjected to temperatures below approximately 400°F. This method is used to join metals such as iron, copper, nickel, lead, tin, zinc, and many of their alloys. Soft solders are tin-lead alloys, with or without the addition of other elements, and may be applied with either the soldering "iron" (copper) or a torch.

Note. - The terms "soldering copper" and "soldering iron" have the same meaning. For simplicity, the term "soldering iron" will be used throughout this text.

b. Hard soldering (silver soldering). The hard soldering method is used when the materials to be joined are subjected to temperatures above the melting temperature of soft solder or when a stronger joint is required than can be made by using soft solder. Hard soldering is often called "silver soldering" or "silver brazing". Hard soldering (silver soldering, or silver brazing) has been covered in section V of this lesson. The remainder of this section will be devoted to the fundamentals and general application in the soft soldering field only.

29. TYPES AND FORMS OF SOLDER.

a. Types of solder.

(1) The most common material used as a soft solder bond is an alloy composed of 50 percent tin and 50 percent lead. This is known as "half and half" or 50/50 solder, the tin content being represented by the first figure. Solders having various other proportions of tin to lead, such as 60/40, 40/60, and 30/70, may be obtained for use on certain jobs.

(2) It is essential that the solder "set" or alloy with the metal surface on which it is applied. Tin is the principal "wetting" or alloying element of soft solders; lead is added to decrease the cost of the mixture and because it has a low melting point (like tin). Solders with a high lead content cool slower than solders containing mostly tin; therefore, they leave a smoother joint.

(3) The 50/50 solder, which reaches the plastic stage at approximately 300°F and turns liquid at 415°F, is suitable for soldering automobile radiators, electrical connections, copper tubing, copper. sheet, brass, cast iron, galvanized iron, and sheet steel. An alloy of 60 percent tin and 40 percent lead is generally used where the temperature of the work requirement is critical. This alloy has a very narrow plastic range; it becomes plastic at approximately 360°F and liquid at approximately 370°F. Solders containing 30 percent tin and 70 percent lead are specially used for filling dents and welding joints on automobile bodies; they have a wide plastic range and are most suitable to this type of work. This solder becomes plastic at approximately 360°F and remains mostly in that state until approximately 495°F, when it turns to a near liquid form.

b. Forms of solder. Soft solders are manufactured commercially in solid 1 pound bars and wire forms (fig 20). Solder is also obtainable in special forms such as pellets, rings, washers, and other unusual forms for special applications. Wire solder is wound on a spool and may be solid or contain a core of compressed powdered rosin (rosin core solder) or acid (acid core solder). Cross sectional views of a solid and several acid and rosin core solders are shown in figure 21. To prevent the liquid acid from leaking from the acid core solder, the solder is crimped at short intervals. Wire solder is designated by number, and the core size determines the ratio of solder to flux, regardless of strand size, type of flux, or alloy use,

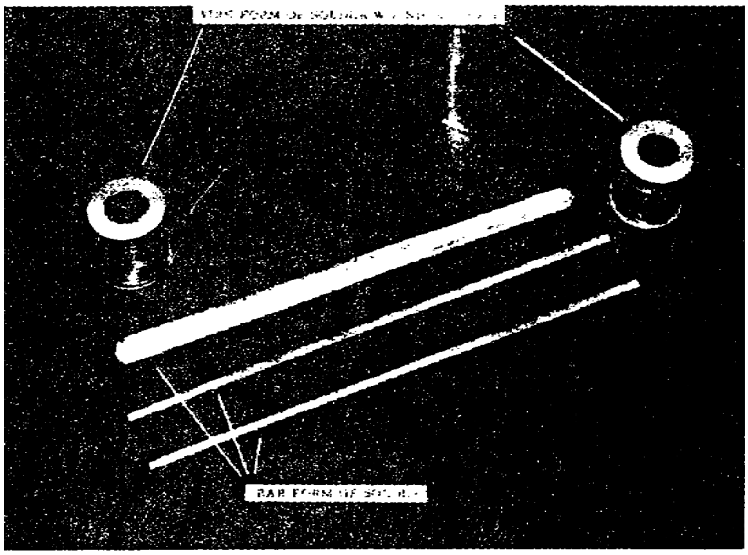


Figure 20. Forms of soft solder.

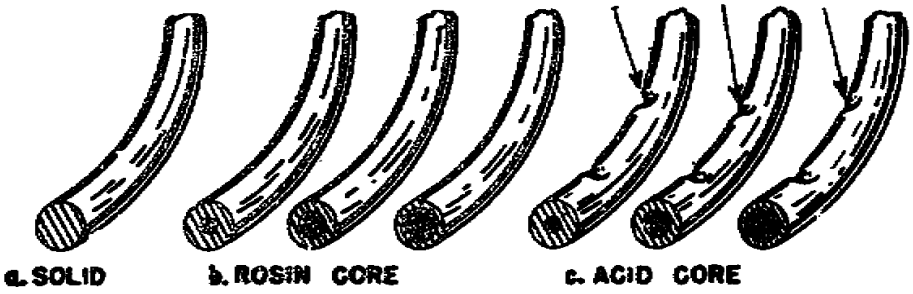


Figure 21. Forms of wire solder.

30. FLUXES.

a. Types of flux.

(1) General. There are two classes of flux: corrosive and noncorrosive. A corrosive flux, such as borax, sal ammoniac, or zinc chloride, is used when soldering galvanized iron, zinc, iron, and steel. A corrosive flux should seldom be used on electrical work as it eats away the metal being soldered. When a corrosive flux has been used, the joint must be thoroughly cleaned to remove any trace of flux that may be left on it, thus preventing the flux from eating away any of the material. Noncorrosive fluxes, such as stearine, rosin, and tallow, are used when soldering tin, copper, lead, etc. The noncorrosive flux prevents the forming of oxide and cleans the metal surfaces without eating away any of the surface material. Rosin is the most common noncorrosive-type flux.

(2) Process. In order to have a cleansing effect on a metal surface, the flux used must melt at or below the fusing point of the solder, and it must prevent any oxidation by excluding the air during the soldering process. Different metals solder better with different fluxes: therefore, the manufacturer's recommendations should be followed whenever possible.

(3) Liquid flux. Liquid fluxes are usually salts of acids in solution; for example: zinc chloride dissolved in water. All liquid fluxes, with the exception of rosin dissolved in alcohol, are corrosive. The residue of the salt solution left on the work after soldering must be thoroughly removed to prevent deterioration of the soldered joint. Liquid rosin flux is noncorrosive, and its residue need not be removed.

(4) Paste flux. Soldering pastes may be acid- or nonacid-type fluxes. They consist of grease or wax containing an acid or nonacid flux. Acid pastes are corrosive, and their residue must be removed. Nonacid pastes, such as petrolatum (e.g., vaseline) mixed with rosin, are noncorrosive but should also have their residue removed to prevent dust and dirt from collecting on the finished work. This is particularly important in soldering electrical connections, because the dust and paste mixture may form a short circuit. In all work in which pastes are used as fluxes, the joints should be thoroughly cleaned to remove any excess grease.

b. Preparation of zinc chloride. Zinc chloride flux is made from hydrochloric (muriatic) acid by placing the acid in an earthenware container and adding a few pieces of zinc to "cut" it. This causes a vigorous chemical reaction. Enough zinc should be added to "kill" the acid; that is, until all reactions have stopped. The reaction produces explosive hydrogen gas; therefore, the preparation of the solution should be done outdoors. After the solution has been strained through several thicknesses of cloth, it is ready for use. Hydrochloric acid may be used, without adding zinc, as a cleaning agent on heavily oxidized surfaces. When using hydrochloric acid on zinc and galvanized iron, the zinc metal or the zinc in the galvanized coating combines with the acid to form zinc chloride flux.

31. SOLDERING IRONS. Soldering irons are heated by one of two methods -externally or internally. The externally heated iron may be heated by a blowtorch, bunsen burner, portable fire pot, etc. The internally heated iron is heated by an electrical heating element.

a. Flame-heated iron (nonelectric). The ordinary flame-heated soldering iron consists of a tip made of solid copper 3 or 4 inches long, usually octagonal in cross section with a tapered point on one end and a steel rod to which a suitable wooden handle is fastened (fig 22). Soldering irons are rated according to weight. Selecting the proper size or weight iron is important. A heavy iron will hold heat longer than a light one; however, a medium or lightweight iron is easier to handle and is more suitable for small jobs. Beginners should start by using a medium weight iron. The lightweight flame-heated iron is generally used by radiator repairmen, electricians, etc, who require only a little solder at a time and an easily manipulated tool that retains sufficient heat for a short period. This type of soldering tool, however, requires repeated heating over an open flame.

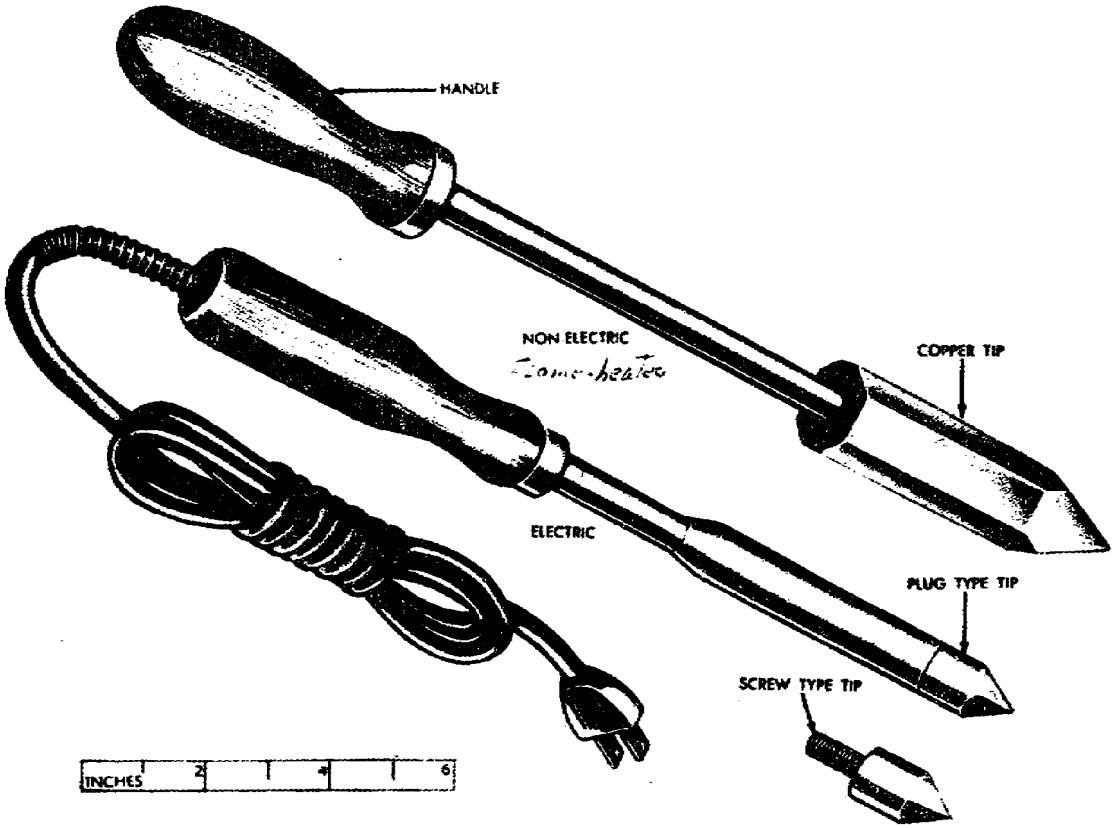


Figure 22. Soldering irons.

b. Electric iron. The electric soldering iron is a more convenient tool to use if a 110-volt alternating or direct current is available (fig 22). This iron is obtainable In different sizes (100-, 200-, 300-, and 500-watt). The 100- and 200-watt sizes are used for light work, the 300-watt for medium work, and the 500-watt for heavier work. A variety of tips are also available for use on special jobs. The electric iron heats quickly and remains uniformly hot until the current is turned off, thereby permitting faster work than with externally heated irons. If the electric iron becomes too hot for a given job, the current can be turned off for a few minutes to allow the iron to cool to a suitable soldering temperature. Automatic electric soldering irons also have been developed that have a thermostatic unit, similar to that found in electric flatirons, to limit and control the temperature.

32. GASOLINE BLOWTORCH.

a. General. The gasoline blowtorch (fig 23) is commonly used as a means of heating the flame-heated soldering iron. However, with proper adjustment of the flame, it may also be used as a soldering torch.

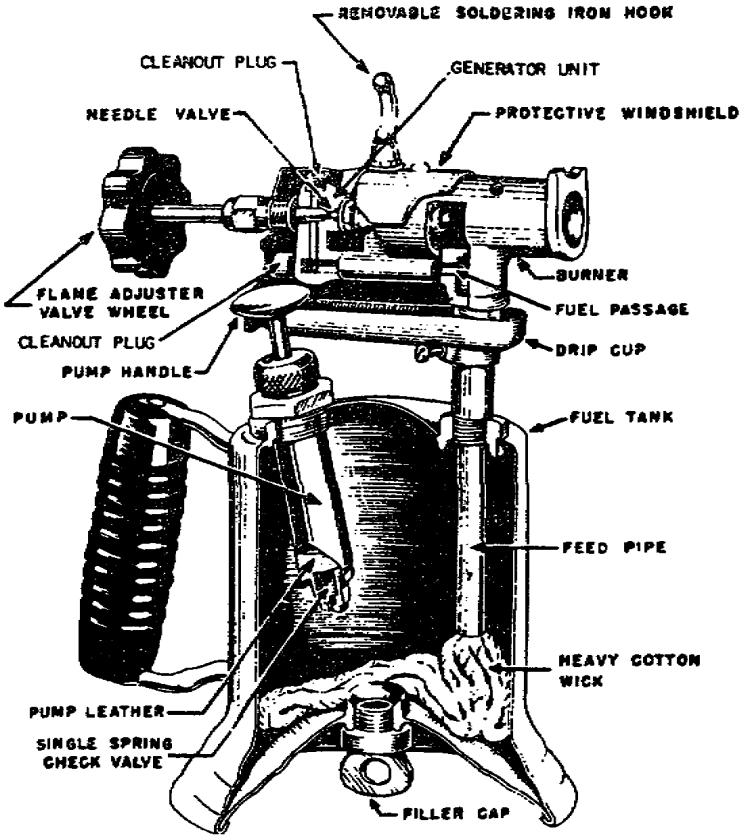


Figure 23. Gasoline blowtorch.

b. Filling the fuel tank. To fill the fuel tank, the torch is turned upside down and the filler cap unscrewed from the bottom. The tank is filled three-fourths full, thus allowing sufficient space to build up the proper air pressure above the fuel level. (White or unleaded gasoline should be used as fuel in blowtorches.) The cap is then replaced tightly and the torch set upright. A tank pressure of only a few pounds should be pumped in by operating the pump handle approximately 30 strokes for starting purposes -another 10 strokes are added after lighting.

c. Igniting. Before lighting the torch it is necessary to preheat the burner. A little gasoline should be run into the drip cup directly under the burner by opening the flame adjuster valve and holding a flat object against the mouth of the burner for a few seconds to prevent gasoline from escaping by directing it into the drip cup. The flame adjuster valve is then closed (all excess gasoline should be wiped off the torch with a rag) and the gasoline in the drip cup ignited. It is important for the torch not to be in draft so that the preheating flame will be concentrated on the burner. Just before the flame in the drip cup burns out, the needle valve must be opened slightly (by turning the flame adjuster valve wheel) to allow gasoline to enter the heated burner; this causes the liquid gasoline to vaporize as it enters the burner and produce a hot flame. A steady blue flame is desired (insufficient preheating of the burner is indicated by an irregular yellow flame). While the blowtorch is in operation, the air pressure in the tank must be maintained to insure a forceful operating flame.

d. Adjusting the flame. The flame adjustment for the gasoline blowtorch is made by turning the flame adjuster valve wheel - counterclockwise to open the valve and clockwise to close it. Opening the valve produces a longer and hotter flame, while closing the valve produces a shorter and less intense flame. When the torch is used for heating the soldering iron, adjustment of the flame will depend upon the size of the iron to be heated. When the torch is used as the soldering tool, the flame adjustment to obtain proper heat will depend upon the size of the area to be soldered.

e. Extinguishing the flame. To extinguish the flame of a blowtorch, the needle valve should be closed gently - never too tight, as this will enlarge the precision orifice and damage the delicate valve seat. When the torch is hot, the valve seat is in an expanded state and the needle (if closed tightly) would be turned into the orifice too far, causing it to jam and stick when the torch cools and the metal contracts. As a precautionary measure, the needle valve should always be backed out slightly after the flame is extinguished, but not enough to allow any fuel to escape.

Note. - It is well to make a safety check after the torch has cooled, to determine if gasoline is seeping or dripping from the blowtorch burner.

f. Maintenance. The most frequent cause for malfunctions of the blowtorch is that of carbon deposits forming in the small fuel passage. These deposits may be removed by unscrewing the cleanout plugs and hand twisting a small drill of exact size into the passage. When a drill of the proper size is not available, a short length of stiff wire may be used.

Note. - One cleanout plug is in the top of the generating unit behind the soldering iron hook, the other below the needle valve (fig 23).

CAUTION: It is important to choose a drill of the proper size since a drill too large will cut out and enlarge part of the passageway and a drill too small will not remove all the carbon deposits.

33. OXYACETYLENE EQUIPMENT. The oxygen-acetylene torch and apparatus used for soldering is the same as that used for welding and brazing which has been covered in sections III and V of this lesson. The flame used for soldering is the reducing or carburizing flame.

34. SOLDERING PRINCIPLES.

a. Introduction. Soldering with externally heated or electric soldering irons may be quite simple, providing the following factors are remembered:

(1) The correct size and shape of iron must be selected for the particular work to be done, and the tip should be tinned properly.

(2) Solder will not stick to dirty, tarnished, or corroded metals.

(3) The correct type of flux and solder should be used.

(4) The soldering iron must not be overheated.

(5) The area to which the solder is to be applied must be hot enough-to melt the solder, or poor adhesion will result.

b. Preparing the iron. A properly shaped and tinned soldering iron tip is essential for good soldering. The tinning operation is applied to a new iron or to one that has been heated to a temperature so high that the coating of solder has been burned.

(1) Filing.

(a) The tip of the soldering iron is filed to shape the point and to remove old solder, pits, and tarnished spots from the working surface of the iron so that it may be properly tinned.

(b) Before it is filed, the soldering iron should be heated hot enough to melt old solder left on the surface. With externally heated soldering irons, this heating process may be accomplished by several methods. If a hot gas flame such as a bunsen burner is used, the iron should be placed over the burner with the point outside the flame. A gasoline blowtorch may also be used. Using this method, the flame of the torch should be concentrated on the thick end of the iron. Because of the high heat conductivity of copper, the point will be heated to practically the same temperature as its thick end.

(c) If the tip of the soldering iron is badly pitted or uneven, it may be necessary to repoint it. This is accomplished by heating the tip to a dull red and hammering it on an anvil until the point tapers back about one-fourth the total length of the copper portion. The hammer blows should be distributed evenly on the faces. The iron may then be annealed (softened) by being reheated and plunged red hot into cold water to permit filing the point to a finish. The tip of an electric iron should not be hammered, filed, or plunged into water until the heating element has been removed.

(d) A vise or holding clamp should be used to secure the iron while filing. The working surface of the tip should be parallel with the top of the vise or holding clamp. The tip should be filed on all sides until bare metal can be seen, using a fine flat file to prevent cutting away too much metal.

(2) Tinning.

(a) The iron should be heated to the minimum temperature required to make solder flow readily; an overheated iron will not tin properly. An externally heated iron is ready for tinning when the surface appears to be covered with various colors; a green flame coming from the heated tip indicates that it is too hot. Electric iron overheating can be recognized by the sudden tarnishing of the bright metal on a newly filed tip.

(b) After the tip of the iron has been properly heated, it should be rubbed on a block of sal ammoniac flux and solder applied (omit the sal ammoniac flux if core solder is used). All sides of the tip should be tinned for general soldering practices. However, if the job surface requires that the iron be used in an overhead position, only one side of the tip should be tinned. When attempting to solder with the iron in an over-head position, a completely tinned tip will result in the solder flowing away from the joint as shown in figure 24. Excess solder may be wiped off with a clean dry cloth.

(c) The tinned point should be cleaned with a soft wire brush or clean dry cloth each time it is removed from the heat; otherwise it will become coated with the flux residue and oxidation of the solder.

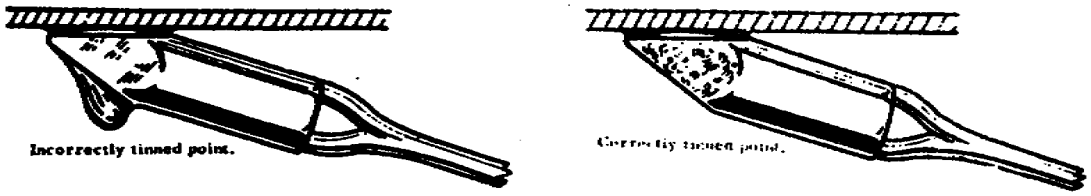


Figure 24. Iron tinned for working on underside:.

c. Preparing the job surface.

(1) Cleaning. Cleaning the surfaces to be joined is an important step in soldering operations. If soldering is not already made impossible by the presence of dirt, rust, corrosion, oil, or grease, any bond obtained will be seriously weakened. Cleaning may be done with a scraper, file, wire brush, emery cloth, or sandpaper. For heavily oxidized surfaces, a solution of muriatic (diluted hydrochloric) acid may be used as a cleaning agent. Cleaning should be considered satisfactory when the portion of the bare metal to be soldered shows a smooth bright surface. The cleaned surface of the metal should not be touched because that will leave a grease stain or perspiration mark that is sufficient to keep the solder from adhering properly.

(2) Fluxing.

(a) To stop the formation -of additional oxide, the cleaned metal surface should immediately be protected from the atmosphere with a coating of flux. The metals to be soldered should be heated by holding the soldering iron flat against the surfaces of the joint as shown in figure 25. A small amount of flux should then be applied to the surfaces of the heated metals. Only a small amount of flux is necessary because when applied to heated metals it spreads rapidly. Liquid flux can be applied with a small brush, swab, or squirt can.

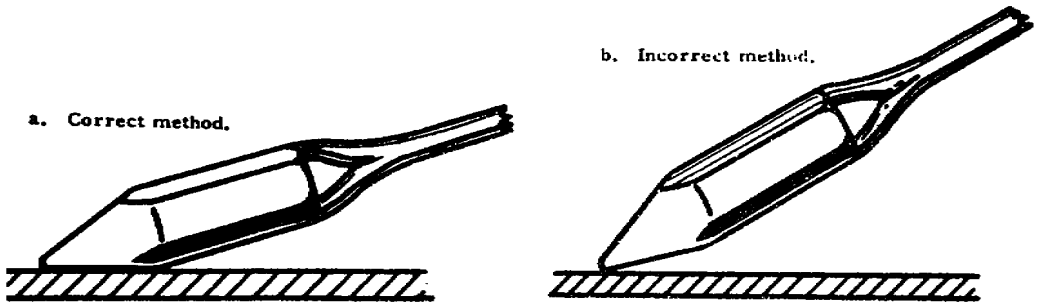


Figure 25. Correct and incorrect methods of using cored solder.

(b) When cut acid is used as a flux, the water in it turns to steam under the soldering heat and is lost. This dries out the flux; therefore, additional water is required to maintain full effectiveness. More water or flux should be applied to the areas of the metal to be soldered while reheating or changing the soldering iron. Unless the flux is refreshed the solder will not bond to the metal.

(c) When using the acid-type or paste flux it is necessary to wash the surface with water to remove all traces of flux residue. When cored solders are used, separate fluxing is unnecessary since the flux and solder are applied in one operation.

d. Applying solder.

(1) Solder should be applied directly to the joint before the flux has a chance to evaporate. The tip of the soldering iron should be kept in contact with the metals being soldered until the solder flows freely over the joint. Heating of the metal should not be continued past this point or the solder will flow away from the joint along the sides of the metal pieces. Insufficient heating of the metals will prevent the solder from flowing freely, creating a weak cold joint.

(2) Bar and solid wire solders may be applied either to the tip of the iron and flowed onto the work or applied directly to the heated surfaces. The latter method is more advantageous because it is easy to tell whether or not the surfaces have been sufficiently heated. The metals to be joined must be heated enough to melt the solder. When using acid core or rosin core solders, the solder should not be applied directly to the hot tip of the iron and dripped on the work but should be applied directly on the surface (fig 25A). Melting acid or rosin core solders on the hot tip will cause evaporation of the flux, possibly resulting in an imperfect joint. After using acid core solders, the end of the solder wire should be crimped before storing to prevent loss of acid.

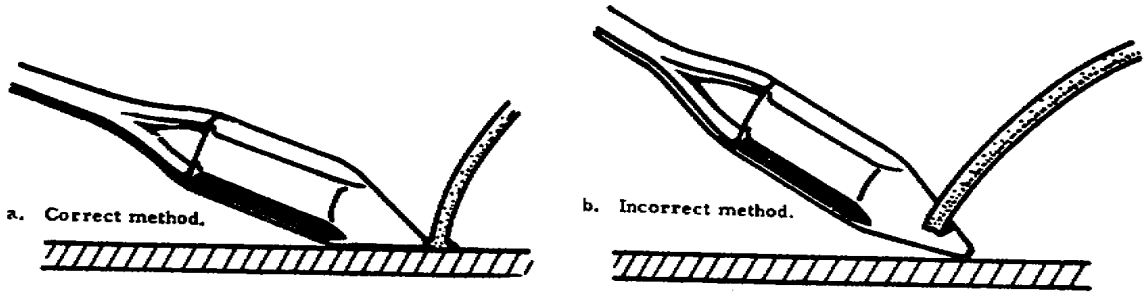


Figure 25A. Correct and incorrect methods of using cored solder.

(3) When soldering large joints, the movement of the soldering iron is important. When the iron is moved too slowly, the molten solder tends to spread away from the joint being soldered. If the iron is moved too rapidly, the solder will not have a chance to melt completely, the cracks in the joint will not be filled, and a weak joint will result. When soldering heavy materials, the iron should be moved slowly. On light materials, whose melting point approaches that of the solder, the iron should be held at one spot no longer than necessary to melt the solder thoroughly. When using a very hot soldering iron, the angle of the iron should be shifted as the work progresses so that more and more of the flat tinned surface of the tip comes in contact with the surfaces being soldered. This procedure will keep the applied heat more constant. With an electric soldering iron, no shifting is necessary, for its heat remains stable.

e. Sweating a lap-joint. The process of "sweating" two metal surfaces together is widely used for joining sheet metal (fig. 26). In this operation, the particular areas of the surfaces to be joined must first be thoroughly cleaned, fluxed, and tinned. When the metals have cooled, the tinned surfaces are again fluxed and then lapped. While holding the surfaces in close contact, heat is applied to the untinned outer side of the job with either a soldering iron or torch. This will melt the solder between the metals and bond them as they cool.

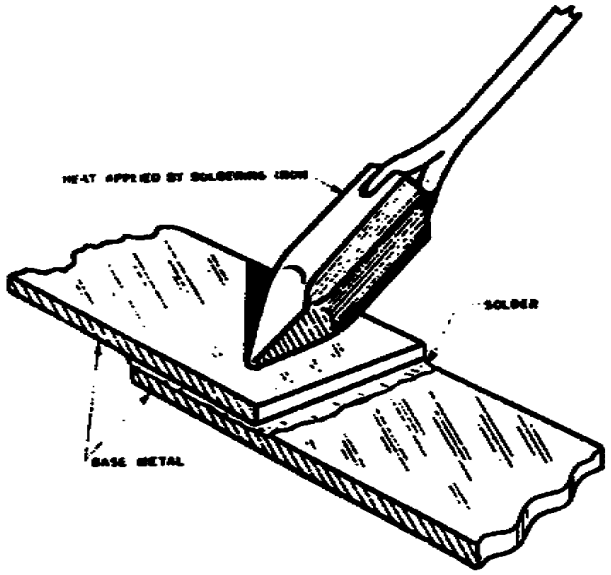


Figure 26. Method of sweating a lap-joint.

35. SOLDERING WITH A TORCH.

a. Common uses. Torches are used to heat large or heavy metal areas for soldering. When speed is required, a hand torch is preferable to the soldering iron, and many times the torch can be used to reach out-of-the-way places that cannot be reached with the soldering iron; e. g., the inner parts of a radiator core. The torch is also very useful for melting soldered joints when dismantling parts.

b. Method of using torch.

(1) The method of applying solder using a torch does not vary greatly from soldering with an iron, Procedures for the cleaning and fluxing of metals to be soldered are the same as those described in paragraph 34c. However, when applying solder, the flame of the torch is applied to the metal surfaces at the same time as the solder.

(2) The requirements of a satisfactory torch flame are:

(a) A flame that will not be extinguished by the fumes of the flux.

(b) A flame giving enough heat to accomplish soldering quickly, yet not too hot to damage the metal surfaces being soldered,

(c) A flame that can be adjusted to suit the needs of the job, such as a long, slim needle-pointed flame capable of reaching out-of-the-way places or a wide flame for dismantling of parts or for heavy metal areas.

c. Precautions. The flame from a blowtorch or oxyacetylene torch can produce intense heat and should not be used close to flammable substances, nor should it be used for soldering wires or components around engines. The intense heat may burn the insulation from wires and other components. When torches must be used in a confined space, it is suggested that all demountable parts be removed for the soldering operation. This will prevent possible damage to those parts.

EXERCISE

45. What type of joint would be made when brazing two plates 1/4 of an inch thick or more?

a. V-groove
b. Butt
c. Scarf

46. What type of flame gives the best results when brazing?

a. Neutral
b. Oxidizing
c. Reducing

47. What type of solder would normally be used to repair radiators?

a. 60/40
b. 50/50
c. 30/70

48. Which type of soldering flux is noncorrosive?

a. Borax
b. Zinc chloride
c. Rosin

49. What type of flame is used to solder using oxygen-acetylene equipment?

a. Oxidizing
b. Reducing
c. Neutral

50. When soldering large joints what will cause the solder to spread away?

a. Soldering iron is moved too slow
b. Improper flux
c. Insufficient heat

36. SUMMARY. In this lesson we have discussed safety as applied to oxygen and acetylene welding and cutting operations; setting up oxygen and acetylene welding equipment for welding, brazing, soldering, and cutting operations; and soldering methods using soldering irons both electric and nonelectric. All operations should be performed systematically in order to avoid mistakes. There are many ways to bond metal as was shown by the welding process chart, but only the methods you will be mostly associated with in the field and in normal operations have been listed. You should have learned enough to properly supervise the use of equipment covered by this lesson.

ANSWER SHEET

FOR STUDENT USE ONLY, DO NOT RETURN.

	a	b	c		a	b	c		a	b	c		a	b	c
1.	104	501	536	51.	164	415	533	101.	199	301	614	151.	645	219	548
2.	223	657	595	52.	629	195	520	102.	693	131	459	152.	128	583	254
3.	421	309	243	53.	311	505	498	103.	431	607	250	153.	321	453	676
4.	241	483.	527	54.	167	239	323	104.	281	480	512	154.	171	364	620
5.	375	166	612	55.	304	442	227	105.	561	286	318	155.	653	237	464
6.	690	110	427	56.	631	350	590	106.	115	507	238	156.	435	692	146
7.	562	290	420	57.	677	206	425	107.	601	222	419	157.	560	102	337
8.	630	197	463	58.	389	402	147	108.	414	190	659	158.	310	532	270
9.	579	143	661	59.	316	638	403	109.	355	611	172	159.	214	475	571
10.	547	685	342	60.	194	553	268	110.	687	439	329	160.	678	162	348
11.	289	578	231	61.	393	570	477	111.	140	381	569	161.	428	613	114
12.	635	409	235	62.	284	367	109	112.	384	667	193	162.	201	552	443
13.	429	396	636	63.	207	545	648	113.	610	118	556	163.	509	373	660
14.	103	112	529	64.	422	138	508	114.	149	447	209	164.	180	481	230
15.	119	336	178	65.	615	504	417	115.	462	335	623	165.	357	272	554
16.	510	276	452	66.	145	407	218	116.	338	666	404	166.	586	366	174
17.	236	382	524	67.	580	205	376	117.	108	224	300	167.	343	151	686
18.	101	490	362	68.	621	177	603	118.	599	664	142	168.	120	519	495
19.	521	391	369	69.	468	669	320	119.	306	121	640	169.	626	246	314
20.	628	378	426	70.	134	497	694	120.	183	470	273	170.	487	652	203
21.	486	124	582	71.	385	448	170	121.	625	346	515	171.	285	433	540
22.	541	492	242	72.	200	555	307	122.	484	255	399	172.	618	155	361
23.	326	133	597	73.	674	184	516	123.	217	698	436	173.	473	658	249
24.	293	485	637	74.	567	260	682	124.	334	503	139	174.	211	566	489
25.	248	330	288	75.	228	608	161	125.	593	388	291	175.	182	351	681
26.	152	295	423	76.	372	141	696	126.	111	650	331	176.	308	466	588
27.	296	591	643	77.	549	665	210	127.	633	252	479	177.	538	265	105
28.	573	390	432	78.	444	220	313	128.	216	438	528	178.	445	187	646
29.	537	213	256	79.	688	559	173	129.	411	198	671	179.	153	542	312
30.	192	264	117	80.	100	344	531	130.	558	169	398	180.	234	655	458
31.	581	471	341	81.	245	405	460	131.	368	697	275	181.	670	283	550
32.	279	617	324	82.	360	440	624	132.	144	467	656	182.	302	430	148
33.	691	577	292	83.	600	365	122	133.	476	502	123	183.	574	317	240
34.	259	679	298	84.	233	526	339	134.	602	258	450	184.	165	345	564
35.	347	572	129	85.	565	282	271	135.	229	303	598	185.	325	663	261
36.	156	594	278	86.	175	684	488	136.	168	441	305	186.	622	176	456
37.	179	563	491	87.	434	150	575	137.	472	680	125	187.	592	269	616
38.	465	584	188	88.	651	363	154	138.	359	157	576	188.	208	517	327
39.	215	634	482	89.	225	474	672	139.	534	380	244	189.	585	413	107
40.	457	627	356	90.	400	136	352	140.	675	221	401	190.	377	673	132
41.	437	523	333	91.	371	535	202	141.	287	589	606	191.	135	319	461
42.	349	639	274	92.	513	266	446	142.	354	695	189	192.	683	185	370
43.	277	394	647	93.	106	654	543	143.	641	297	499	193.	494	251	525
44.	539	496	699	94.	644	262	454	144.	163	596	386	194.	544	469	232
45.	113	408	392	95.	387	518	181	145.	546	322	257	195.	267	530	649
46.	522	397	299	96.	159	374	605	146.	226	449	514	196.	668	263	455
47.	191	642	412	97.	557	127	332	147.	418	130	609	197.	315	160	632
48.	358	662	253	98.	410	619	212	148.	506	395	196	198.	137	511	340
49.	500	379	416	99.	247	451	587	149.	294	604	406	199.	568	383	280
50.	116	493	204	100.	328	551	186	150.	424	158	353	200.	478	689	126

RESPONSE NUMBER	RESPONSE
101	Refer to para 3b(1).
103	Refer to para 6e(3)(a).
104	Refer to para 4b.
110	CORRECT. Holding capacity is generally 1-1/2 to 3 inches and normally do not have pipe holding jaws.
112	CORRECT . To read a micrometer the first thing is to record the highest figure visible on the barrel. Then count the number of lines between that figure and the thimble edge. Next, take the reading on the thimble and add all three for the reading.
113	CORRECT. The V-groove should be beveled to include a 90° angle.
116	CORRECT. If the soldering iron is moved too rapidly the solder will not have a chance to melt. Proper heat application is very important in making a good bond.
117	Refer to para 14b(5).
119	CORRECT. The graduations on the metric micrometer must be changed; however, the same principle is applied in reading both types of micrometers.
124	CORRECT. The effective length would be approximately 11/16 inch with the total length of thread 1 inch.
129	Refer to para 7e(l).
133	Refer to para 8b(3).
143	CORRECT. When using snips there is danger of metal fractures along the edges of the metal during the shearing process.
152	Refer to para 9c(2).
156	Refer to para 11c(3).
166	Refer to para 4e(l)(e) and fig 29.
178	Refer to para 6e(3){b).
179	CORRECT. Threaded fittings for acetylene are left-handed. Oxygen hoses are green and acetylene hoses are red.
188	CORRECT. This type flame is advantageous for welding high carbon steel, for hard facing operations, and for welding nonferrous alloys such as nickel and monel.
191	Refer to para 29a(3).

192 CORRECT. If the reamers are only slightly dulled the edges can be honed on an oilstone, but special jigs are required to sharpen the edges correctly and this is a factory or depot operation.

197 Refer to para 5c(3}{d).

204 Refer to para 34d(3).

213 CORRECT. Prior to coating the pipe the male and female threads must be inspected and if necessary cleaned with a stiff brush.

215 Refer to para 16a(l).

223 Refer to para 4c(2)(d).

231 Refer to para 5f(5).

235 Refer to para 6b(l)(a)c.

236 Refer to para 3a(2)(c).

241 Refer to para 4d(8).

242 Refer to fig 15.

243 Refer to para 4d.

248 Refer to para 9b(l).

253 CORRECT. Rosin flux is the most common noncorrosive type flux. This type flux prevents the forming of oxide and cleans the metal surfaces without eating away any of the surface material.

256 Refer to para 12a(2)(c).

259 Refer to para 7c(2).

264 Refer to para 14b(5).

274 Refer to fig 16.

276 Refer to para 2a.

277 Refer to para 20e.

278 Refer to para 11c(3).

279 CORRECT. Too much heat will increase the pressure which may cause the safety fuse in the cylinder to blow out.

288 CORRECT. Turning the wrench too fast or too slow will cause the reamer to chatter and will produce an unevenly reamed hole.

289 CORRECT. This punch is ground to a slender, long tapered, cone-shaped point terminating in a sharp 30° conical tip.

290 Refer to para 5b(3)(h).

292 CORRECT. Opening the valve the full limit prevents leakage around the valve stem.

293 CORRECT. A quarter turn clockwise on the handle for each complete revolution gives the wheels a "bite" on the pipe until the pipe is cut.

295 Refer to para 9c(2).

296 Refer to para 10b.

298 CORRECT. The automotive exhaust method is also considered acceptable by military personnel. The two methods are considered easiest.

299 Refer to para 24c.

309 Refer to para 4d.

324 Refer to para 6b(6).

326 Refer to para 8b(3).

330 Refer to para 9b(l).

333 Refer to para 17e.

336 Refer to para 6e(3)(b).

341 Refer to para 6b(4).

342 CORRECT. The cape chisel is also used for cutting narrow grooves and square corners.

347 CORRECT. Soda ash is used on other metals but not on aluminum. Chlorinated hydrocarbons are not used at all.

349 CORRECT. The cutting oxygen pressure and cutting speed must also be considered in order to make a neat cut.

356 Refer to para 17b.

358 Refer to para 30a(l).

362 Refer to para 3b(l).

369 CORRECT. Some other types of check valves are swing, disk, and adjustable check.

375 CORRECT. Other special purpose pliers are brake spring, glass holding and breaking, ignition and brake key, and snapring.

378 Refer to para 5a(3).

379 CORRECT. This type flame burns with a coarse rushing sound and has a temperature of approximately 5.700°F at the inner cone tips.

382 Refer to para 3a(2)(c).

390 Refer to para 10c(l)(a).

391 Refer to para 4b(5).

392 Refer to para 23b.

394 Refer to para 20e.

396 Refer to para 6d(2)(c).

397 CORRECT. Use a slightly oxidizing flame, heat to the correct temperature, and apply small quantities of filler rod material as needed.

408 Refer to para 23b.

409 CORRECT. A hook rule has a sliding hook which facilitates measuring from a shoulder. Figure 41 shows a hook rule.

412 Refer to para 29a(3).

416 Refer to para 33.

420 Refer to para 5b(3)(h).

421 CORRECT. Width and shape of blade tips vary from a narrow parallel sided tip to a wide tapered tip. Some have special tips.

423 CORRECT. Turning the wrench counterclockwise will cause the tool to become dull, fail to cut, and become useless.

426 Refer to para 5a(3).

427 Refer to para 4f(l)(c).

429 Refer to para 6d(2)(c).

432 Refer to para 10c(l)(a).

437 Refer to para 17e.

452 Refer to para 2a.

457 Refer to para 17b.

463 CORRECT. This blade is used on solid stock, aluminum, babbitt, tool steel, high speed steel, and cast iron.

465 Refer to para 13b(3).

471 CORRECT. Also, never use acetylene from cylinders without reducing the pressure with a suitable pressure reducing regulator.

482 CORRECT. Fluxes are used to get rid of oxides. Fluxes are not designed to remove oil, grease, or other foreign substances.

483 Refer to para 4d(8).

485 Refer to para 8c(7).

486 Refer to fig 11.

490 CORRECT. These type fittings can be used with either rigid or flexible copper tubing and are made in the usual iron pipe patterns.

491 Refer to para 11d(3).

492 CORRECT. The minimum bending radius would be not less than 1-3/4 inches.

493 Refer to para 34d(3).

496 Refer to para 20g(5).

500 Refer to para 33.

501 CORRECT. The ball peen hammer has a round ball-shaped head and is used for all general purpose work.

510 CORRECT. Pipe is also furnished plain (black) or galvanized and normally in 21-foot lengths.

521 Refer to para 4b(5).

522 Refer to pars 24c.

523 CORRECT. If this action is timed correctly, both the rod and base metal will melt at the same time.

524 CORRECT. Type K is used for underground or heavy-duty purposes and type L is used for general indoor plumbing.

527 CORRECT. Also, use the longest screwdriver available which is convenient to work with. Oil or graphite on machine screws help to drive the screws easier. Use soap on wood screws.

529 Refer to para 6e(3)(a).

536 Refer to pars 4b.

537 Refer to pars 12a(2)(c).

539 CORRECT. A welding rod can also be used to start a cut on heavy sections .

541 Refer to fig 15.

547 Refer to par 5e(3).

562 CORRECT. The three-sided file tapers toward the point, is double cut, and has fairly sharp corners. Refer to figure 35.

563 Refer to para 11d(3).

572 Refer to para 7e(l).

573 CORRECT. The retreading die will cut American Standard coarse and fine threads and the adjustable die will cut both Standard coarse and fine threads plus standard sizes used in Britain and other European countries.

577 Refer to para 6c(7).

578 Refer to para 5f(5).

579 Refer to para 5d(1)(b).

581 Refer to para 6b(4).

582 Refer to fig 11.

584 Refer to para 13b(3).

591 CORRECT. Mud taps and staybolt taps are considered special purpose taps.

594 CORRECT. By using a two-stage regulator the oxygen is reduced from high to intermediate and then to working pressure. This pressure is constant and adjustments during welding operations are not required as they are on the single-stage regulators. Working pressure on a single-stage regulator must be adjusted as the cylinder pressure falls.

595 CORRECT. Socket wrenches have two openings: one a square which fits the handle and the other a circular hole with notched sides to fit the bolt, screwhead, or nut to be turned.

597 CORRECT. A double flaring tool has the additional feature of adapters that turn in the edge of the tube before a regular 45° flare is made.

612 Refer to para 4e(l)(e) and fig 29.

617 Refer to para 6b(6).

627 CORRECT. Also, keep the end of the luminous cone about 1/16 of an inch away from the base metal.

628 CORRECT. End-to-center measure is also used to measure a piece of pipe having a fitting screwed on one end only.

630 Refer to para 5c(3)(d).

634 Refer to para 16a(l).

635 Refer to para 6b(l)(a)2.

636 CORRECT. This type caliper is used for measuring recesses where the setting cannot be transferred to a scale directly because the legs must be collapsed to remove them from the work.

637 Refer to para 8c(7).

639 Refer to fig 16.

642 CORRECT. 50/50 solder is one-half tin and one-half lead. It is also used for electrical connections, copper tubing, brass, cast iron, galvanized iron, and sheet metal.

643 Refer to para 10b.

647 CORRECT. As soon as the plate is perforated the torch is again lowered to the normal height above the work to complete the cut.

657 Refer to para 4c(2)(d).

661 Refer to para 5d(l)(b).

662 Refer to para 30a(1).

679 Refer to para 7c(2).

685 Refer to para 5e(3).

690 Refer to para 4f(1)(c).

691 Refer to part 6c(7).

699 Refer to part 20g(5).